National Aeronautics and
Space Administration

May 26, 1995

NRA-95-OLMSA-03

RESEARCH ANNOUNCEMENT

Microgravity Combustion Science: Research and Flight Experiment Opportunities

Letters of Intent Due: .... July 10, 1995

Proposals Due: .... August 25 1995

OMB Approval No. 2700-0042

MICROGRAVITY COMBUSTION SCIENCE: RESEARCH AND FLIGHT EXPERIMENT OPPORTUNITIES

NASA Research Announcement
Soliciting Research Proposals
for the Period Ending
August 25, 1995

NRA-95-OLMSA-03
Issued: May 26, 1995

Office of Life and Microgravity Sciences and Applications
National Aeronautics and Space Administration
Washington, D.C. 20546-0001

NASA RESEARCH ANNOUNCEMENT
MICROGRAVITY COMBUSTION SCIENCE:
RESEARCH AND FLIGHT EXPERIMENT OPPORTUNITIES

TABLE OF CONTENTS

NASA RESEARCH ANNOUNCEMENT

MICROGRAVITY COMBUSTION SCIENCE: RESEARCH AND FLIGHT OPPORTUNITIES

This NASA Research Announcement (NRA) solicits proposals for flight experiments and for ground-based experimental and theoretical microgravity research in combustion science. The combustion science discipline represents a broad range of research areas including but not limited to gaseous flames (premixed and non-premixed), droplet, particle, spray, and dust flames, ignition and flamespread over solid surfaces, smoldering combustion, and combustion synthesis of novel materials. More complete descriptions of the microgravity combustion science research activities and interests are given in Appendix A.

Investigations selected for flight experiment definition must successfully complete a number of subsequent development steps, including peer review of the flight experiment, in order to be considered for a flight assignment. NASA does not guarantee that any investigation selected for definition will advance to flight experiment status. Proposals are sought for a number of flight opportunities beginning in 1998. Investigations selected for support as ground-based research under the Microgravity Science and Applications Division (MSAD) Research and Analysis (R&A) Program generally must propose again to a future Announcement in order to be selected for a flight opportunity.

Participation is open to U. S. and foreign investigators and to all categories of organizations: industry, educational institutions, other nonprofit organizations, NASA centers, and other U. S. Government agencies. Though NASA welcomes proposals from non-U.S. investigators, NASA does not fund principal investigators at non-U.S. institutions. Proposals may be submitted at any time during the period ending August 25, 1995. Proposals will be evaluated by science-peer reviews and engineering feasibility reviews.

Appendices A and B provide technical and program information applicable only to this NRA. Appendix C contains general guidelines for the preparation of proposals solicited by an NRA.

This Announcement will not comprise the only invitation to submit a proposal to NASA for access to the reduced-gravity environment. The Shuttle missions and other opportunities are an ongoing process, and it is anticipated that other Announcements will be issued as opportunities become available for additional investigators.

Proposals and Letters of Intent mailed through the U.S. Postal Service by express, first class, registered, or certified mail are to be sent to the following address:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
Washington, DC 20546-0001

Proposals and Letters of Intent hand delivered or sent by commercial delivery or courier services are to be delivered to the following address between the hours of 8AM and 4:30PM:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
ATTN: Receiving and Inspection (Rear of Building)
300 E Street, SW
Washington, DC 20024-3210

The telephone number (202) 488-2940 may be used when required for reference by delivery services. NASA cannot receive deliveries on Saturdays, Sundays, or federal holidays.

Solicitation Identifier:	NRA-95-OLMSA-03
Copies Required:	15 (proposal); 1 (letter of intent)
Selecting Official:	Director Microgravity Science and Applications Division Office of Life and Microgravity Sciences and Applications

Additional information may be obtained from Dr. Merrill K. King at the above address (Telephone Number: (202) 358-0817) or from:

Mr. Thomas H. Acquaviva
Space Experiments Division
Mail Stop 500-115
Lewis Research Center
National Aeronautics and Space Administration
Cleveland, OH 44135-3191
Telephone: (216) 433-8020

Your interest and cooperation in participating in this effort are appreciated.

Harry C. Holloway, M.D.
Associate Administrator for
Life and Microgravity Sciences and Applications

APPENDIX A

NRA-95-OLMSA-03

Technical Description

MICROGRAVITY COMBUSTION SCIENCE: RESEARCH AND FLIGHT EXPERIMENT OPPORTUNITIES

I. INTRODUCTION

A. BACKGROUND

NASA's Microgravity Science and Applications Division (MSAD) conducts a program of basic and applied research in microgravity to improve the understanding of fundamental physical, chemical, and biological processes. In this program, NASA sponsors investigations by university, industry, and Government researchers using both ground-based and space-flight facilities.

The combustion science discipline is an established focus of the microgravity science and applications program. The Division released NASA Research Announcements (NRA's) for combustion science in 1989 and in 1993 and now expects to release NRA's in combustion science approximately every two years. Other disciplines with periodically released solicitations are biotechnology, materials science, and fluid physics. For additional information on research opportunities available through the Microgravity Science and Applications Division, contact:

Dr. Roger K. Crouch
Code UG
National Aeronautics and Space Administration
Washington, DC 20546-0001
Telephone: (202) 358-0818
Telefax: (202) 358-3091

B. RESEARCH ANNOUNCEMENT OBJECTIVES

The combustion science program seeks a coordinated research effort involving both space- and ground-based research. Ground-based research forms the foundation of this program, providing the necessary experimental and theoretical frameworks for development of rigorous understanding of basic combustion phenomena. This research can eventually mature to the point where it becomes the focus of a well-defined flight experiment. This NRA has the objective of broadening and enhancing the MSAD microgravity combustion science program through the solicitation of:

1. Experimental studies which require the space environment to test clearly posed hypotheses, using existing or slightly modified instruments in space-based experiments to increase the understanding of combustion;

2. Experiment concepts which will define and utilize new instruments for space-based experiments in combustion science; and

3. Ground-based theoretical and experimental studies which will lead to the definition or enhance the understanding of existing or potential flight experiments in combustion science.

Further programmatic objectives of this NRA include objectives broadly emphasized by the civil space program, including: the advancement of economically significant technologies; technology infusement

into the private sector; and enhancement of the diversity of participation in the space program, along with several objectives of specific importance to the microgravity science and applications program. These latter objectives include the support of investigators in early stages of their careers, with the purpose of developing a community of established researchers for the International Space Station and other missions in the next 10-20 years, and the pursuit of microgravity research that shows promise of contributing to economically significant advances in technology.

C. DESCRIPTION OF THE ANNOUNCEMENT

With this NRA, NASA is soliciting proposals to conduct research in microgravity combustion science, with an emphasis on experimental efforts that are sufficiently mature to justify near-term flight development. The goals of the discipline along with some identified research areas of interest are described in Section II. Proposals describing innovative low-gravity combustion science research beyond that described herein are also sought.

NASA is currently developing several types of flight instruments for microgravity combustion science research. Brief descriptions of the planned capabilities are given in Appendix B. NASA anticipates future flight opportunities for investigations with requirements which can be met by existing apparatus with only minor modifications. Successful proposals for use of the existing apparatus will be funded for advanced definition studies which will produce a detailed Science Requirements Document (SRD). Authorization to proceed into flight development is contingent upon successful peer review of the experiment and SRD by both science and engineering panels. NASA does not guarantee that any experiment selected for definition which plans to use existing hardware will advance to flight experiment status.

NASA also encourages submission of experiment proposals for which none of the existing flight instruments is appropriate. NASA anticipates the development of new combustion science research experiment apparatus and diagnostic tools for use in 1998 and beyond. Descriptions of possible future capabilities can also be found in Appendix B. These hardware descriptions are included as examples to allow researchers to consider the type of capabilities that might meet their science requirements. However, researchers should not feel limited by these capabilities.

Selected proposals requiring development of new capabilities will be funded for flight definition studies to determine flight experiment parameters and conditions and the appropriate flight hardware. The length of the definition phase will be based on the experiment requirements, but will normally range from 6 to 24 months and will culminate in the preparation of an SRD.

Authorization to proceed into flight development is contingent upon successful peer review of the SRD by both science and engineering panels. NASA does not guarantee that any experiment selected for flight definition which requires new instrument development will advance to flight experiment status. Investigations that do not proceed into flight development will normally be asked to submit a proposal for continuation of support at the conclusion of a typical four-year period of funding.

Promising proposals which are not mature enough to allow development of a flight concept within two years of definition may be selected for support in the MSAD Research and Analysis (R&A) Program. Investigations selected into the R&A program must generally propose again to a future announcement in order to be considered for a flight opportunity.

II. MICROGRAVITY COMBUSTION SCIENCE RESEARCH

A. INTRODUCTION/BACKGROUND

Combustion is a key element of many critical technologies used by contemporary society. For example, electric power production, home heating, surface and air transportation, space propulsion, and materials processing and synthesis all utilize combustion. Undoubtedly, as worldwide economic development accelerates, the role of combustion for energy production and other industrial activities will continue to expand. Yet, although combustion technology is vital to achieving and improving our standard of living, it also poses some of the greatest challenges to maintaining a habitable environment. For example, control

2

of pollutants, atmospheric change and global warming, unwanted fires and explosions, and the incineration of hazardous wastes are major current problem areas which would benefit from improved understanding of combustion. Thus, combustion phenomena influence our lives in many ways and have an unusually large impact on major problems facing us today. The major goals of combustion science are: (1) to understand, from a fundamental perspective, the interactions between fluid dynamics, scalar transport, thermodynamics, and chemical kinetics making up combustion processes, and; (2) to provide predictive and design capabilities to enable and enhance combustion energy utilization and fire safety.

Effects of gravitational forces on earth impede combustion studies more than they impede most other areas of science. Combustion intrinsically involves the appearance of high-temperature gases whose low density triggers buoyant motion, vastly complicating the execution and interpretation of experiments. Perversely, the effects of buoyancy are strongest in the highest temperature regions of flames (where most of the chemical reactions occur) causing these zones, where current understanding is most limited, to collapse into thin sheet-like regions that can not be resolved by existing or anticipated instrumentation. Buoyant motion also triggers the onset of turbulence, yielding unsteady effects as an additional complication. Finally, gravitational forces cause particles and drops to settle, inhibiting studies of heterogeneous flames important to furnace, incineration and power generation technologies. Thus, gravity seriously limits our capabilities to carry out experiments needed to develop an understanding of flame phenomena.

The microgravity environment provides a reduction of buoyancy forces, inhibition of particle or droplet settling, and often a reduction in dimensionality (spherical symmetry for burning droplets, for example). The major reduction in buoyancy associated with microgravity allows the study of many phenomena with much higher resolution since length scales can be increased. As an example, Reynolds number or Peclet number similarity can be held under microgravity conditions with increase in the length scale and compensating decrease in the velocity scale, while at normal gravity such changes would result in a large increase in the Grashof number and thus a shift in the balance between buoyancy and other effects; thus, buoyancy might be negligible under the original conditions, but significant under the larger length-lower velocity conditions chosen for improvement of resolution. (Under microgravity conditions, the magnitude of the Grashof number will be insignificant under both the original and the scaled conditions.) In addition, the microgravity environment presents an opportunity to treat gravity as an independent parameter for experiments in which buoyancy plays an important role under normal gravity conditions.

The problem presented by normal gravity in studies of combustion is best defined by examination of several dimensionless groups which appear in non-dimensionalized governing equations. One of these is the Grashof number referred to in the last paragraph, a number which expresses the ratio of buoyant to viscous forces. In combustion phenomena, large gas density differences result from the non-uniform temperature fields produced by the heat release involved, leading to strong buoyancy forces. While this does not create a problem for very small length scales (order of 100 microns) even at normal gravity, such small scales result in severe experiment design and measurement problems. In the case of forced convection, the dimensionless group normally used is the Richardson number, which expresses the relative effect of buoyancy-induced velocity to the forced velocity. If the laminar burning velocity of a premixed gas flame is the appropriate velocity, buoyancy effects can be neglected only for laminar flame speeds above about 1 m/s, a value near the upper limit of flame speeds even for near stoichiometric mixtures and far above flame speeds near flammability limit conditions, of particular interest in many studies. For nonpremixed jet flames, the Reynolds number based on forced convection velocity must be large compared to the square root of the Grashof number for buoyant velocities to be negligible compared to the forced convection velocity; it is easily shown that this condition precludes study of the Stokes flow regime, of interest in droplet burning, at normal gravity. In normal gravity, laminar flame experiments tend to be strongly influenced by buoyancy, while in practical turbulent-flow combustion devices, buoyancy effects are negligible; these factors strongly compromise the use of the laminar flamelet concept to apply data obtained in normal-gravity laminar flame experiments to analysis of the practical turbulent flames, while microgravity laminar flame results are not similarly compromised.

Numerous types of instabilities are possible in gas mixtures used to study turbulent flames, some of these being gravity-dependent and others not. Accordingly, study of flame instabilities under microgravity conditions can be used to better define causes of instability under various conditions. In addition, the absence of settling effects under microgravity conditions offers the opportunity for much more fundamental studies of soot formation and agglomeration processes in gas or droplet flames, as well as less ambiguous studies of droplet, spray, and particle cloud combustion.

Anyone who has observed the combustion of solid fuels, particularly flame spread across and burning of vertical walls, is well aware of the dominant effects of buoyancy on such processes under normal gravity conditions, a dominance which makes understanding of other phenomena involved very difficult (an example of how buoyancy can "mask" such phenomena). Accordingly, microgravity studies of flame spread across solid fuels (and liquid pools) are of considerable interest from a fundamental point of view as well as being very important in terms of fire safety on various space platforms.

At this time, experience with microgravity combustion experiments is limited but promising. Test times for relatively accessible ground-based microgravity facilities are short, making them most appropriate for preliminary experiments. Access to the long-duration microgravity environment of space has been restricted to a small number of experiments with modest instrumentation on the Space Shuttle. Nevertheless, microgravity combustion experiments are fulfilling our expectations. This includes observations of classical fundamental flame phenomena that are not possible due to disturbances from buoyancy on earth: the propagation of premixed flames near flammability limits, relevant to lean-burn technology for pollutant reduction as well as explosion safety; droplet combustion at pressures extending up to the thermodynamic critical point, relevant to diesel engine, aircraft jet engine and rocket engine technologies; nonbuoyant flame spread along the surfaces of solids and liquids, relevant to fire safety and the cleanup of fuel spills; soot processes in nonbuoyant flames, relevant to the emissions of soot and other pollutants from a broad range of combustion processes; heterogeneous premixed flames in particle clouds, relevant to explosions in grain elevators and mines; and one-dimensional smoldering, relevant to fire safety. Clearly, discoveries from fundamental microgravity combustion experiments will, at the least, help to rewrite the textbooks on combustion science in the coming decades.

In addition to fundamental studies, ground and shuttle-based microgravity combustion experiments have been motivated by concerns about spacecraft fire safety. The concerns about spacecraft fire safety come about from NASA's ongoing commitment and high priority to reduce the risks of operations aboard spacecraft such as the Shuttle and the international space station. Findings thus far suggest that fire signatures—heat release, smoke production, flame visibility and radiation—will be quite different in space from our Earthbound experience. Consequently, a better understanding of fire behavior in microgravity is needed to provide more assurance to those people whose lives depend on the environment aboard our spacecraft.

B. CURRENT PROGRAM

In order to acquaint potential proposers with the current makeup of the NASA Microgravity Combustion program, a brief description of studies currently being funded is given in the following paragraphs. It should be emphasized that proposals are not limited to these areas; in fact, we specifically encourage proposals outside these areas to help us broaden the scope of our activities.

The Microgravity Combustion research program encompasses experimental, theoretical (analytical and numerical), and diagnostic development tasks addressing the combustion of gaseous, liquid, and solid fuels. Included in the gaseous fuel studies are tasks involving both premixed and nonpremixed (diffusion) flames. In terms of flow characteristics, these studies include stationary flames, laminar flow flames, and turbulent flow flames. In terms of configurations, combustion of fuel jets injected into quiescent surroundings, co-flowing streams, and counterflow flames are included. In the area of liquid combustion, we support studies of combustion of individual droplets, droplet arrays, and sprays, as well as flame spread

across and combustion of liquid fuel surfaces. In closely related studies, we are examining combustion of solid particles. The study of ignition of and flame spread across solid fuel surfaces is an important area of concentration in our program. In other studies involving solid fuels, we are supporting study of smoldering combustion and of combustion synthesis of novel materials. In each program, a vital element is the use of microgravity, either to reduce the complexity of the problem by removal of buoyancy effects or provision of a perfectly one-dimensional spherical geometries not attainable in the presence of gravity, or to provide an additional independent parameter to permit more rigorous evaluation of theoretical models.

In the area of premixed gas combustion, we are currently funding a study of the effects of gravity-induced buoyancy on the combustion limits of premixed flames, with concentration on: (1) Radiation effects on premixed gas flames; (2) Flame structure and stability at low Lewis numbers; (3) Flame propagation and extinction in cylindrical tubes; and, (4) Experimental simulation of combustion processes using autocatalytic reactions. Experiments are being conducted both at normal gravity and at low gravity (KC-135 tests); in addition a major test matrix is planned for the MSL-1 space mission in 1997. In support of this program, we are also funding numerical computations and analytical modeling studies, with an objective of understanding mechanisms by which flameballs stabilize in a quiescent premixed gaseous fuel-oxidizer environment.

Also in the area of premixed gas combustion, we are supporting an experimental investigation of the dynamics of low Reynolds' number premixed turbulent flames in a microgravity environment. This study places major emphasis on measurement of flame wrinkle scales and imaging of mean flowfield properties of conical Bunsen-type flames and rod-stabilized v-flames, with laser diagnostics being used to obtain statistical scalar and velocity information needed for predicting effects of gravity on turbulent premixed flames. Another investigation involves study of turbulent premixed flames in a Couette-flow configuration, with information obtained in these experiments being used to validate a novel computational method for accurate simulation of premixed flames. (For full understanding of the behavior of turbulent flames, access to all length scales in the flow field is required; reduced flow velocity offers access to these scales, but is not possible at normal gravity due to buoyancy effects.)

Another of our current investigators is directing a program aimed at understanding and quantifying structure , stabilization mechanisms, soot formation in, and extinction of 1D premixed and nonpremixed laminar flames. During 1994, a series of tests providing the first observations of flames stabilized near a burner by virtue of flow divergence only was completed; this work provides a new fundamental method for evaluating adiabatic flame speeds for premixed flames.

In still another premixed gas flame investigation, a method which will produce high-quality quantitative color-enhanced digital images of a vortex exerting aerodynamic strain on a flame under microgravity conditions is being utilized This study will be used to quantify how the vortex distorts the flame, define the degree of flame curvature, and show how preferential diffusion affects flame profiles. Images of the flame shape will be used to assess numerical simulations which do not include buoyancy effects and to deduce universal buoyancy-free scaling relations showing the effects of vortex size and strength. Observations from this study are being utilized in two modeling investigations of turbulent premixed flames. In the first of these, direct numerical simulation studies are being used to examine scenarios in which parallel fuel and oxidizer streams enter the computational domain and react. Questions addressed include: (1) How does buoyancy affect small-scale structure of the scalar and velocity fields; (2) How does buoyancy affect scalar dissipation near the reaction zone; (3) When is the flamelet concept valid for buoyant turbulent diffusion flames; and, (4) How does flame extinction depend on appropriate dimensionless numbers, reaction energy level, and orientation of gravity to the fuel-air interface. Another PI is also performing computational studies of the structure and dynamics of premixed flames in normal gravity and microgravity environments, using a different approach; In this study, he is systematically isolating and evaluating the relative importance of various chemical and physical processes which may be controlling the structure and dynamics of premixed flames and comparing predictions with the experimental observations.

Another PI is investigating the adequacy of frequently adopted simplified mathematical models of the behavior of laminar flames, mainly diffusion flames, by comparison with experimental data which can be obtained only in a microgravity environment. In this study, the plan is to initially segregate hydrogen diluted with argon and oxygen diluted with helium into two equal half-volumes; a thin parylene film will

5

initially separate the gases with perforation on command by an array of prongs, some of which will serve as spark electrodes. Flame temperature and position will be measured as a function of time.

Also in the area of gaseous diffusion flames, in a follow-up to a previous Glovebox study performed on board the shuttle, the features of microgravity candle flames are being examined. Specific objectives of this study are: (1) Observe whether a steady flame can exist in a purely diffusive environment; (2) Understand previously observed near-extinction flame oscillations; and, (3) Examine the nature of interactions between two candle flames. These objectives will be accomplished by a program consisting of development of a comprehensive numerical model of the candle flame, ground testing in normal-gravity laboratories and drop towers, and another glovebox experiment involving several upgrades relative to the previous glovebox experiment .

In another program, we are attempting to quantify conditions under which a stabilized laminar diffusion flame will be extinguished by radiative heat losses from flame-generated particulates (e.g., soot) that drain chemical energy away from the flame; microgravity conditions are required since radiation-induced extinction is generally not possible at normal gravity where buoyancy-generated convection sweeps the radiating sources up and away from the flame.

Several studies of the flow structures of gas-jet diffusion flames are underway. In one program, the PI is studying the effects of energy release on the near field flow structure of gas jet flames to improve understanding of how buoyancy affects the shear layer structure, development of fluid dynamic instabilities, and formation and characteristics of coherent structures in the near-nozzle regions of such jets, with a secondary objective of understanding the role of buoyancy in flame lifting and reattachment processes. Another PI is studying the effects of large-scale structures on transition and turbulent flow regimes in jet diffusion flames. This program includes a Getaway Special Cannister (GASCAN) experiment on the shuttle, using controlled, well-defined disturbances to reveal the mechanisms which govern the dynamics of large-scale structure interaction with flame fronts under microgravity conditions; this will further our understanding of the naturally occurring disturbances which are inherent to transitional and turbulent gas-jet diffusion flames. In a related program, still another PI is examining techniques for controlling turbulent structures in flames using techniques of active and passive control of fluid dynamics. A specific goal of this research is determinationof the influence of buoyancy on the three-dimensional fluid dynamics of the interaction between a diffusion flame and the elliptic vortex rings formed by pulsations of flow from an elliptic nozzle.

We are also currently supporting a study aimed at improved understanding of the influence of buoyancy on co-flow diffusion flames (e.g., Burke-Schumann flames) and on vortex-flame interactions in co-flow diffusion flames. Modeling and normal gravity experiments to date have revealed a harmonic response in flame height and temperature in Burke-Schumann flames pulsed at 1 to 4 Hertz, indicating that buoyancy is an important factor in this nonlinear flame response.

Another PI is studying aerodynamic, unsteady, kinetic, and heat loss effects on the dynamics and structure of weakly-burning flames in microgravity, utilizing a counter-flow burner geometry to provide a nearly adiabatic flame with well-controlled strain for conditions that cannot be obtained in normal gravity. Both premixed and diffusion flames will be studied at various pressures, with Laser Doppler Velocimetry and Particle Imaging Velocimetry diagnostics being employed.

A study of the effects of chemical inhibitors on diffusion flames under microgravity conditions has recently been initiated (Fire suppression in space is a major reason for investigation of combustion in microgravity.) Specific goals of this program include determination of the effects of halogenated fire suppressants on the physical characteristics of gaseous diffusion flames at microgravity conditions and development of quantitative analytical models.

A major problem in diffusion flames is the production of soot by those flames. A critical flight experiment in this area is being developed as part of an experimental and theoretical investigation of mechanisms of soot formation in laminar jet diffusion flames at low buoyancy conditions. In this program, the applicability of flamelet theory to extend these results to turbulent jet diffusion flames is being investigated. In another investigation in this area, the PI is modeling soot formation and radiation for such turbulent flames, determining modeling coefficients from data obtained under normal and microgravity conditions.

Another recently initiated study involves determination of the structure and dynamics of stationary spherical flames and the coupled processes occurring in liquid and gas phases associated with burning of liquid fuels. Included are modeling of flame instability in pool burning and diffusional-thermal instabilities in diffusion flames.

In the area of combustion of liquid droplets, we are funding a major flight program to study unsteady liquid and gas phase phenomena and extinction of fuel droplets. The major component of the experimental program will be carried out as a mid-deck experiment on MSL-1 since microgravity conditions are required to provide the symmetry conditions needed for comparison of modeling predictions and experimental results. In addition, the PI is directing a study of the high-pressure combustion of miscible binary fuel droplets, while another investigator is also studying combustion of 2-component miscible droplets in reduced gravity, though with different emphasis.

The effects of sooting on droplet combustion characteristics are being studied with use of optical and intrusive diagnostics; parameters to be examined include burning rate, flame dynamics, extinction, disruption of the burning droplet, and soot particle dynamics. Particular concentration is being placed in this study on accurate measurement of soot volume fraction, temperature, and soot morphology and dynamics. Another PI will shortly begin a program to provide insights and supply data regarding the role of immiscible and miscible metal-containing additives in fuel droplet combustion and to examine the effects of initial droplet diameter on microgravity combustion; here again there is particular interest in the question of soot formation in the burning of such droplets.

Important to progress in microgravity studies of fuel droplet combustion is development of improved diagnostic tools; we are currently funding two programs in this area. The first is an investigation of the range of applicability of advanced diagnostics to droplet combustion in microgravity conditions. (Prioritized measurement parameters are flame front position, relative gas flow around droplets, droplet surface transport and internal flow, and liquid-phase thermometry.) The second involves development of rainbow thermometry for quantitative radial temperature measurements in burning droplets and use of Morphologically-Dependent-Resonances for quantification of the regression rate of such droplets.

In the area of combustion of multiple fuel droplets, one step closer to the practical situation of combustion of fuel sprays, another PI is studying combustion of one-and-two-dimensional arrays of droplets in a buoyancy-free environment to extend the data base and theories that exist for single droplet combustion into a regime where droplet interactions are important. As part of this activity, an apparatus for the Fiber-Supported Droplet Combustion Glovebox Experiment (manifested on USML-2) has been built and tested. In addition, two studies of spray combustion under microgravity conditions are underway.

In the closely related area of combustion of solid particles, we have recently funded a study of combustion characteristics of spherical PMMA particles in reduced gravity, the first attempt to study the combustion of a solid sphere under microgravity conditions. The 1-D configuration simplifies data interpretation in providing fundamental information for solid fuel combustion science. Another PI is investigating the mechanisms of ignition and combustion of metals in bulk-pellet form under low-pressure atmospheres over a range of gravity levels, while still another PI has recently begun an experimental and analytical study to determine the mechanisms by which oxygen penetrates within a burning metal droplet and affects the combustion process. In this last study, a novel apparatus is utilized for generation of uniformly-sized droplets; these droplets are then ignited and subsequently quenched to terminate the reactions at prescribed times. In microgravity, the near-absence of settling forces permits precise control of the droplet motion to permit accurate interpretation of the droplet-diameter and droplet-temperature histories.

In the area of combustion of fuel surfaces, experiments aimed at resolution of the effects of buoyancy on flame spread across liquid fuel pools using normal gravity and microgravity experiments with advanced diagnostics (notably rainbow schlieren deflectometry and particle imaging velocimetry) and numerical modeling at arbitrary gravity levels are underway. Of special interest in this work is determination of whether and under what conditions pulsating flame spread can occur in microgravity (under the absence of buoyancy in either the liquid or the gas phase). Recently, the first in a series of three sounding rocket tests was successfully completed.

There are several investigations of ignition and flame spread across solid fuel surfaces underway in the Microgravity Combustion program. Spreading of flames over solid fuels is a fundamental problem with practical significance in prevention and control of fires; microgravity experiments eliminate complexities associated with buoyancy effects, providing a more fundamental scenario for development of flame spreading theory. Included in the programs being funded in this area are studies of flame spread under quiescent (no gas flow) conditions, propagation of flames over solid fuels against a low velocity forced flow of oxidizer (without the complicating effects of buoyancy, whose induced flow would dominate this controlled forced flow), and propagation of such flames in the same direction as an imposed crossflow velocity. Thin fuels and thick fuels are both being utilized in these studies. In one specific program, a series of eight tests has been carried out on Shuttle flights, due to the need for relatively long periods of microgravity conditions forced flow. Specific objectives are experimental observation of flame shapes, gas-phase field variables, spread rates, radiative characteristics, and solid-phase regression rates for comparison with theory, and investigation of the transition from ignition to flame propagation or extinction. Emphasis is being placed in some of these experiments on the effects of radiative heat transfer on flame spread, through imposition of external radiant heating and direct measurement of radiant losses. The combination of the various tests completed to date provide the first comprehensive measurements of flame spread behavior over a single material over the full range of conditions from "high-speed" flows in the concurrent direction, through low-speed flows in reduced gravity (transitioning from concurrent to opposed flow) to "high-speed" flows in the opposed direction.

In this area, one investigator is conducting an experimental study of the radiative ignition of fuel surfaces and subsequent transition to flamespread over those surfaces in low gravity in the presence of very low speed airflows in 2D and 3D configurations and comparing the results with theoretical model predictions. A radiant heater and/or hot wire is used to ignite samples of cellulose of various thicknesses and/or compositions; variables considered are flow velocity, irradiated sample diameter or power level, geometry of sample or sample thickness, and metal ion doping of the fuel.

Another PI has recently begun a study of the spread of flames across thin and thick solid fuel surfaces in which the effects of the type of inert gas (which affects Lewis Numbers) are being studied, as are the effects of addition of sub-flammability-limit concentrations of fuel gas to the oxidizing atmosphere. The effect of convection is also being studied through normal gravity and microgravity testing with and without a forced flow. In addition, the influence of thermal radiation is being addressed in this program.

In a recently initiated study, a PI is attempting to develop more fundamental models for the wind-aided spread of flames over thin solid fuels in microgravity. An important unique feature of this study is concentration on the details of the combustion processes in the flame-anchoring region (the so-called "Triple-Flame" zone) and on the fuel pyrolysis chemistry.

In the diagnostics area, we are funding development of a diagnostic based on diode laser absorption spectroscopy for use in microgravity combustion research, with a specific objective of quantitative determination of molecular oxygen. In addition, this activity is aimed at development of an improved understanding of the relative roles of diffusion and reaction of oxygen in microgravity combustion.

As indicated in the preceding paragraphs, the Microgravity Combustion program is currently supporting considerable research in the area of flame spread across solid fuel surfaces; one PI is expanding this research to the study of interactions between flames which are spreading over parallel solid fuel surfaces.

Smoldering is important both as a fundamental combustion problem and as a fire safety problem. In this area, we are funding a study, to culminate in a series of flight experiments in a GASCAN facility on shuttle, to increase understanding of smoldering combustion under normal and microgravity conditions. Experiments are being conducted with polyurethane foam with various mixtures of oxygen and nitrogen. Temperatures at several locations through the test sample are measured with thermocouples, with the resulting temperature histories being used to obtain smolder propagation velocity; experimental results are used to verify and improve theoretical models of smoldering.

Another PI is studying combustion in porous media, with applications to smoldering combustion and combustion synthesis of advanced materials. This is basically a theoretical modeling study, and complements the experimental task described immediately above along with a program in the combustion

synthesis area. The objectives of the latter program are to obtain improved understanding of the effects of gravity on the combustion synthesis of ceramic matrix-metal infiltrated composites and to develop new improved-property materials. To date, considerable effect of gravity level on the various compositions studied have been observed. Also in the area of combustion synthesis, another PI is studying gasless combustion synthesis from elements under microgravity conditions. The objective of this task is to understand the mechanisms of structure formation during combustion synthesis from elemental powders in order to define the most promising ways to control the microstructure and thus the properties of advanced materials; many fundamental questions can be addressed by removal of complications caused by normal gravity processes. This experimental program involves two approaches: macrocombustion, involving combustion synthesis of pellets pressed from reactant powders; and novel microcombustion experiments where reactions of individual reactant particles are studied. Both approaches are to be carried out under normal gravity and microgravity conditions.

Finally, we are funding a study of the fundamental chemical and physical mechanisms associated with the production of ultrafine particles (and the nature of the particles themselves) generated by the thermal breakdown of PTFE wire insulation. The results are expected to contribute to the knowledge of the chemical and physical mechanisms of the process and offer practical applications in the reduction of health hazards and in the early warning detection of fire incidents in spacecraft.

C. PLANS/PRIORITIES FOR FUTURE RESEARCH

A fruitful approach to achieving meaningful technology gains in combustion processes must be centered on development of better understanding of the fundamentals of the unit processes involved. Without such an understanding, the approach taken to improving combustion devices tends to involve incremental trial-and-error perturbations around current state-of-the-art designs, missing opportunities to achieve possible major improvements with radically different approaches to the given combustion problem. However, if one fully understands the physics and chemistry involved in a given combustion process, including detailed understanding of the unit subprocesses and how they interact, this understanding can be combined into physically accurate models which can then be used for parametric exploration of new combustion domains via computer simulation, with possible resultant definition of radically different approaches to accomplishment of various combustion goals. Accordingly, emphasis should be placed on studies which permit exploration of combustion fundamentals which are not currently well understood. As discussed earlier, gravitational effects associated with normal earthbound combustion studies have prevented study of many elementary processes which tend to be overshadowed by gravitation-induced processes such as buoyancy; in addition, gravity-induced settling of particles in two-phase combustion processes and distortion of one-dimensional spherical geometries by buoyancy effects have vastly complicated comparisons of theory and experiment, making it difficult to develop mechanistic understanding of many unit phenomena making up overall combustion processes.

As may be seen, there are many diverse combustion phenomena worthy of investigation; in a world of limited resources, it is important that some selection be made of which areas should be emphasized. Based on the rationale presented above, it appears that studies yielding <u>fundamental</u> information about combustion processes and unit sub-processes are of paramount importance. Combining this objective with the prevalence of certain types of combustion processes in practical applications, the following are tentatively selected as combustion research topics of priority interest:

(1) **Jet Diffusion Flames (With or without coflow)**-- Of major scientific interest are unit processes associated with soot formation in diffusion flames and with the connections between laminar and turbulent diffusion flame processes; microgravity offers unique opportunities for study of these most important problems. Most practical combustion devices using gaseous fuels (such as natural gas) involve diffusion flames.

(2) Propagating Premixed Gas Flames-- Much fundamental knowledge, particularly in the areas of flammability limits and flame stability, is available via microgravity experimentation. This knowledge is particularly important both for hazards analysis and for the development of fuel-lean combustion devices for improved fuel utilization efficiencies.

(3) Quasi-Steady-State Gas Spherical Premixed and Diffusion Flames-- These flames, utilizing point-source injection for attainment of a spherical geometry (possible only under microgravity conditions with the accompanying disappearance of buoyancy forces) permit major improvements in the study of gas flame kinetics, likely of significant utility in analysis of many practical combustion devices, particularly as applies to use of alternative fuels.

(4) Droplet Combustion-- Microgravity environment offers a unique chance for study of very important fundamentals of this process which cannot be studied under normal-gravity conditions due to buoyancy-induced geometry distortions. In terms of practical applications, combustion of droplets (oil, gasoline sprays as examples) is involved in a major fraction of industrial and transportation processes utilizing combustion.

(5) Heterogeneous Combustion--Fundamental processes of flames on fuel surfaces, including flame spread along solid and liquid surfaces, smoldering, and combustion synthesis processes, are of major interest. Knowledge in this area is important for hazards analysis, development of new approaches to pollution control, and development of new approaches to production of high-value materials.

(6) Transient Combustion Phenomena--Such phenomena as ignition, extinction, and unsteady response of flames to externally imposed perturbations (e.g, pressure oscillations) are of major importance as regards fire safety, production of pollutants, and combustion efficiency. Again, research studies in a microgravity environment provide for examination of fundamental phenomena involved in these transient phenomena without the confounding effects of buoyancy-induced flows which will, under normal gravity conditions, also respond in an unsteady manner to such imposed perturbations, often masking the fundamental phenomena of interest. With understanding of these phenomena, strategies for controlling ignition, extinction, and responses of flames to externally imposed perturbations in a favorable fashion can better be devised.

The development of criteria for prioritizing combustion subtopics is difficult. However, it appears possible to reduce our over-riding considerations to two major objectives: (1) Making major breakthroughs in understanding the basic science (physics and chemistry) associated with various combustion processes to permit these processes to be 'laid bare"; and, (2) Defining technology approaches that will lead to major improvements in fuel utilization, pollution minimization, hazards abatement, and production of high-value-added materials via combustion processes. To some extent, of course, these goals are interactive, but it must be recognized that one can be achieved without the other in specific programs. At this point, the Microgravity Combustion Discipline Working Group (DWG) has tentatively ranked three areas as being of highest priority:

(1) Turbulent reacting flows (turbulent premixed and diffusion flames), chosen because this is considered by many to be the foremost unresolved combustion problem and because most practical flames are turbulent.

(2) Heterogeneous combustion (droplets/particles and surfaces), chosen since condensed fuels are involved in approximately 85% of applications and because of fire safety issues.

(3) Laminar homogeneous gas flames, of importance as regards pollution and hazards issues, as well as providing an optimum scenario for extraction of fundamental combustion kinetic information.

Beyond the question of prioritization of topic areas, the DWG has suggested that the following factors should be taken into account in judging the merits of proposed programs:

1. Is microgravity of fundamental importance to the proposed study?

2. Are the key issues addressed by the research important topics with the potential for closing of major gap(s) in understanding of the fundamentals of combustion processes?

3. Does the potential exist for identifying/elucidating previously unknown phenomena or interactions between phenomena?

4. Is the project likely to have significant benefits/applications to ground-based as well as space-based operations involving combustion processes?

5. Are the results likely to be broadly useful and lead to further complementary theoretical or experimental studies?

6. Can another project in the particular subarea involved be justified in terms of allocation of limited resources?

7. Is the project technologically feasible---are substantial new technological advances required for successful completion?

8. How will this project stimulate research and education in the combustion area, and what will be its impact on future MSAD combustion activities?

9. What are the costs and future cost implications of this project? How does the projected cost/benefit ratio of this project compare with those of other projects competing for the same resources?

10. What is the potential of this project in terms of stimulating technological developments which will reach beyond the project itself?

11. Are the project goals consistent with broader public policy objectives such as national economic growth or human welfare?

Historically, the instrumentation utilized in low-gravity research studies has been primitive compared to that available in Earth-based-gravity laboratories. While these studies have revealed the promise of microgravity, advances in utilizing/understanding the full potential of extended periods of reduced gravity will be realized only when mapping of temperatures, velocities, species concentrations, and condensed phase properties can be obtained. Thus, the development or utilization of extensive and/or innovative diagnostic capabilities should receive serious consideration for combustion experiments in microgravity.

Finally, as indicated earlier, we strongly encourage submission of proposals for study of combustion phenomena/processes not being covered in our current program; however, reiterating for emphasis, the proposer must keep in mind that a microgravity element is an essential requirement of any proposed study, whether experimental or analytical.

III. EXPERIMENTAL APPARATUS AND FLIGHT OPPORTUNITIES

A. EXPERIMENTAL APPARATUS

In order to address aspects of the research described in Section II, a number of pieces of flight hardware are being developed by NASA. These are described in Appendix B. NASA also contemplates the development of new research capabilities for combustion experiments, also described in Appendix B. In addition, Appendix B lists the ground-based facilities that are available to support definition studies.

Early flight opportunities under this NRA will be on the Space Shuttle with experimental apparatus being either in the Spacelab or middeck, allowing astronaut interaction, or in the cargo bay. Residual acceleration levels on the order of 10^{-4} g are available in the Shuttle for limited periods of time. The Space Acceleration Measurement System (SAMS) is expected to be available to measure and record actual accelerations at or near the apparatus during experiments. Flight durations range from 7 to 16 days. A high-capacity communications network supports Shuttle and payload operations. Downlink channels enable users to monitor their instrument status and science data streams in real time. An uplink channel enables them to act on that information. Considerable additional information on the Shuttle accommodations and capabilities can be found in the STS Investigators' Guide (see Bibliography).

B. DIAGNOSTIC MEASUREMENTS

The capability to characterize science experiments in reduced-gravity is essential to scientific progress in this program. NASA, in ground-based normal and reduced-gravity studies, is developing techniques for enhancing imaging and visualization, and improving measurements of temperature, velocity, and particle-size distributions. As these techniques mature, those most required by investigators will be reviewed for space flight development as part of the future flight equipment capability.

C. FLIGHT OPPORTUNITIES

Missions available for this program include several Shuttle missions, missions aboard the Russian Mir space station, and missions on the International Space Station (after 2000).

D. EXPERIMENT DEFINITION AND FLIGHT ASSIGNMENT PROCESS

Ground-based research is usually necessary to clearly define flight experiment objectives. This research may involve experimentation in NASA-provided ground-based facilities, including those which can provide a limited duration low-gravity environment. (These facilities are described in Appendix B.) Successful proposals for flight opportunities will be supported for a ground-based definition phase before review for flight assignment. The amount of support (technical, scientific, and budgetary) and the length of the definition period (usually from 6 months to 2 years) will depend on the specific investigator needs and the availability of resources from NASA. However, in preparing their budget plan for this research announcement, all respondents should estimate their annual costs for four years.

1. Near-Term Flight Opportunities. Successful proposals for use of the existing instruments will be funded for a period of advanced definition work, after which time the investigator will generate a detailed SRD. The SRD, a detailed experiment description outlining the specific experiment parameters and conditions, as well as the background and justification for flight, must be prepared jointly by a NASA-appointed Project Scientist and the Principal Investigator and submitted for peer review. This formal review by both science and engineering panels will determine if space flight is required to meet the science objectives and if instrument capabilities can be provided to meet the science requirements. Following approval by the panels, subject to program resources, continuation support will be awarded and the hardware will be modified to meet the science requirements. NASA does not guarantee that any experiment selected for definition will advance to flight experiment status. Investigations with unresolved science or engineering issues at the review of the SRD may be placed in ground-based status

with support of limited duration (normally from one to three years), and asked to submit a proposal to a subsequent solicitation for further support.

2. Future Flight Opportunities. Successful proposals for the development of new apparatus will be funded for a period of definition. The length of the definition period will be based on the experiment requirements, but will generally be from 6 to 24 months. At the end of the experiment definition phase, the investigator will generate a detailed SRD. Following successful peer review of the SRD by science and engineering panels, the experiment will proceed into flight development and be considered for flight. As with opportunities for existing instruments, NASA does not guarantee that any experiment selected for definition will advance to flight development status, and the possibility exists that investigations may be placed in ground-based status, with continuing support from NASA for a limited period.

3. Ground-Based Definition Opportunities. Promising proposals for experimental research which are not mature enough to allow development of an SRD after two years of definition, and proposals for development of theory in areas of current or potential microgravity experiments, may be selected for support in the MSAD Research and Analysis (R&A) Program. R&A studies are funded for periods of up to four years. A new proposal to a future announcement is required in order to be selected for a flight opportunity or to continue R&A studies if appropriate.

IV. PROPOSAL SUBMISSION INFORMATION

This section provides the requirements for submission of proposals in response to this announcement. The research associated with a typical proposal submitted under this announcement is conducted by a Principal Investigator who is responsible for all research activities and one or more Co-Investigators. Proposers must address all the relevant selection criteria given in Section VIII in their proposal and must format their proposal as described in this section. Additional general information for submission of proposals in response to NASA Research Announcements may be found in Appendix C.

A. LETTER OF INTENT

Individuals planning to submit a proposal in response to this NRA should notify NASA of their intent to propose by sending a Letter of Intent.

All Letters of Intent that are mailed through the U.S. Postal Service by express, first class, registered, or certified mail are to be sent to NASA Headquarters, addressed as follows:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
Washington, DC 20546-0001

Letters of Intent sent by commercial delivery or courier services (e.g. Federal Express) are to be delivered to the following address between the hours of 8 AM and 4:30 PM:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
ATTN: Receiving and Inspection (Rear of building)
300 E Street, SW
Washington, DC 20024-3210

The telephone number (202) 488-2940 may be used when required for reference by delivery services. NASA cannot receive deliveries on Saturdays, Sundays, or Federal holidays. **In addition, letters of intent may be submitted by Telefax to (202) 358-3091.**

The Letter of Intent, which should not exceed two pages in length, must be typewritten in English and must include the following information:

- The potential Principal Investigator (PI) name, position, organization, address, telephone, telex, and telefax number.
- A list of potential Co-Investigators (Co-I's), positions, and organizations.
- General scientific/technical objectives of the research.
- The equipment of interest listed in this NRA, if appropriate.

The Letter of Intent should be received at NASA Headquarters no later than July 10, 1995. The Letter of Intent is being requested for informational and planning purposes only, and is not binding on the signatories. The Letter of Intent allows NASA to better match expertise in the composition of peer review panels with the response from this solicitation. Investigators may also request more detail on the capabilities of the specific equipment that might be utilized to accomplish their scientific objectives and/or items listed in the Bibliography (Section IX).

B. PROPOSAL

Proposals submitted in response to this Announcement must contain at least the following information in the format shown below:

- Title Page
- Table of Contents
- Executive Summary (replaces abstract) (1-2 pages)
- Research Project Description
  - Statement of the hypothesis, objective, and value of this research
  - Review of relevant research
  - Justification for new or further microgravity research
  - Description of Experimental or Analytical Method
  - Data Analysis
  - References
- Appendices
  - Management Plan (appropriate for large or complex efforts)
  - Complete vitae for the PI and all Co-investigators
  - Current and Pending Support
  - Facilities and Equipment (see Appendix C, Section 7-h)
  - Proposed Costs (see Appendix C, Section 7-i)

The title page must clearly identify the research announcement to which the proposal is responding, title of the proposed research, principal investigator, institution, address and telephone number, total proposed cost, proposed duration, and must contain all signatories.

The executive summary should succinctly convey what the proposer wants to do, how the proposer plans to do it, why it is important, and how it meets the requirements for microgravity relevance. The executive summary replaces the proposal abstract. It should be given particularly careful attention by the proposer since this is the only part of the proposal which will be automatically sent to panel reviewers not specifically assigned responsibility for a given proposal. (Typically, a review panel will consist of 8-12 members, three

of whom will be assigned primary responsibility for presenting assessments of a proposal's scientific and technical merits to the rest of the panel; the other panelists will also use the Executive Summary to help them in discussions of the proposal.) If possible, inclusion of an electronic version of the Executive Summary on disk would be greatly appreciated.

While proposers submitting renewal proposals are not required to repeat the background and justification sections provided in their original proposals, it is important that they include a section summarizing what they have accomplished on their current program and how it leads in to their new proposed work.

The management plan is necessary when the proposed research involves large or complex efforts among numerous individuals or other organizations to insure a coordinated effort.

In addition to the required information given in Appendix C, proposers are also requested to:

(1) Provide a justification of the need for low gravity to meet the objectives of the experiment.
(2) Provide a description of the diagnostic measurements that would be required to satisfy the scientific objectives of any proposed low gravity experiments.
(3) Estimate a time profile of reduced-gravity levels needed for the experiment or series of experiments.
(4) Provide for proposed space flight experiments a clear and unambiguous justification of the need to perform the experiment in space as opposed to ground-based reduced-gravity facilities.
(5) Provide a description of a ground-based testing program that might be needed to complete the definition of the space flight experiment requirements in terms of experiment conditions, acceleration levels and durations, control and diagnostic measurement requirements, etc.
(6) Provide a current curriculum vita for the principal investigator and co-investigators, listing education, publications, and other relevant information necessary to assess the experience and capabilities of the senior participants.
(7) Provide a summary of current and pending support for the principal investigator and co-investigators.
(8) Provide a budget plan estimating annual costs for four years. There should be at least one page for each of the four years and one page summarizing the total four-year budget. The information desired is explained below.

The proposal should not exceed 20 pages in length (including figures), exclusive of budget, vitae, appendices and supplementary material, and should be typed on 8-1/2 x 11 inch paper with a 10- or 12-point font. Extensive appendices and ring-bound proposals are discouraged. Reprints and preprints of relevant work will be forwarded to the reviewers if submitted as attachments to the proposal. Proposers should prepare cost estimates by year for a period not greater than four years in preparing budget plans in response to this Research Announcement.

Signed Certifications Regarding Lobbying; Debarment, Suspension and other Responsibility Matters; and Drug-Free Workplace Requirements will be required of all successful proposers during final grant negotiations **but need not be supplied with the proposal.**

Sufficient proposal cost detail and supporting information will facilitate a speedy evaluation and award. Dollar amounts proposed with no explanation (e.g., Equipment: $58,000, or Labor: $10,000) may cause delays in evaluation or award. The proposed costing information should be sufficiently detailed to allow the Government to identify cost elements for evaluation purposes. Generally, the Government will evaluate cost as to reasonableness, allowability, and allocability. Enclose explanatory information, as needed. Each category should be explained. Offerors should exercise prudent judgement as the amount of detail necessary varies with the complexity of the proposal. If the proposer plans to use Government-Furnished-Equipment (e.g., test rigs to be built at NASA/Lewis) this should be spelled out as a footnote in the cost proposal.

Fifteen copies of the proposal must be received at NASA Headquarters by August 25, 1995, to assure full consideration. Send proposals to Dr. King at the address given below. Treatment of late proposals is described in Appendix C.

All Proposals that are mailed through the U.S. Postal Service by express, first class, registered, or certified mail are to be sent to NASA Headquarters, addressed as follows:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
Washington, DC 20546-0001

Proposals sent by commercial delivery or courier services (e.g. Federal Express) are to be delivered to the following address between the hours of 8 AM and 4:30 PM:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
ATTN: Receiving and Inspection (Rear of building)
300 E Street, SW
Washington, DC 20024-3210

NASA cannot receive proposals on Saturdays, Sundays or Federal holidays.

V. NRA FUNDING

The total amount of funding for this program is subject to the annual NASA budget cycle. The Government's obligation to make awards is contingent upon the availability of appropriated funds from which payment for award purposes can be made and the receipt of proposals which the Government determines are acceptable for an award under this NRA.

For the purposes of budget planning, we have assumed that the Microgravity Science and Applications Division will fund 3 to 5 flight experiment definition proposals. These efforts are typically funded at an average of $175,000 per year. It is also anticipated that approximately 10-15 ground-based study proposals will be funded, at an average of $ 80,000-100,000 per year, for up to 4 years. The initial fiscal year (FY) 1996 funding for all proposals will be adjusted, if required, to reflect partial fiscal year efforts. The proposed budget for ground-based studies should include researcher's salary, travel to science and NASA meetings (for a flight investigation, roughly eight meetings per year with NASA should be anticipated, though travel activity will vary over the development of the experiment), other expenses (publication costs, computing or workstation costs), burdens, and overhead. During subsequent years, NRA's similar to this NRA will be issued, and funds are planned to be available for additional investigations.

VI. GUIDELINES FOR INTERNATIONAL PARTICIPATION

NASA accepts proposals from all countries, although this program does not financially support Principal Investigators in countries other than the U.S. Proposals from non-U.S. entities should not include a cost plan. Non-U.S. proposals and U.S. proposals which include non-U.S. participation, must be endorsed by the appropriate government agency in the country from which the non-U.S. participant is proposing. Such endorsement should indicate:

1. The proposal merits careful consideration by NASA.
2. If the proposal is selected, sufficient funds will be made available to undertake the activity as proposed.

16

Proposals, along with the requested number of copies and Letter of Endorsement, must be forwarded to NASA in time to arrive before the deadline established for this NRA. One copy of each of these documents should be sent to:

Ms. Ruth Rosario
Space Flight Division
Office of External Relations
Code IH
National Aeronautics and Space Administration
Washington, DC 20546-0001
USA

All proposals must be typewritten in English. All non-U.S. proposals will undergo the same evaluation and selection process as those originating in the U.S.

Sponsoring non-U.S. agencies may, in exceptional situations, forward a proposal directly to the above address if review and endorsement is not possible before the announced closing date. In such cases, NASA's Office of External Relations Space Flight Division should be advised when a decision on endorsement can be expected.

Successful and unsuccessful proposers will be notified by mail directly by the NASA program office coordinating the NRA. Copies of these letters will be sent to the sponsoring government agency. Should a non-U.S. proposal or U.S. proposal with non-U.S. participation be selected, NASA's Office of External Relations will arrange with the non-U.S. sponsoring agency for the proposed participation on a no-exchange-of funds basis, in which NASA and the appropriate government agency will each bear the cost of discharging its respective responsibilities. Depending on the nature and extent of the proposed cooperation, these arrangements may entail:

1. A letter of notification by NASA; and
2. An exchange of letters between NASA and the sponsoring government agency.
3. An agreement or memorandum of understanding between NASA and the sponsoring government agency.

VII. NASA/NEDO COOPERATIVE ACTIVITIES

Recently, NASA reached agreement with the New Energy and Industrial Technology Organization (NEDO) in Japan to establish a Microgravity Combustion Coordination Group (MCCG) for identifying areas of potential cooperation related to combustion research in a microgravity environment in which each side might utilize facilities of the other side, primarily NASA's Lewis Research Center facilities and the dropshaft (10 second microgravity duration) of the Japanese Microgravity Center (JAMIC). Possible personnel exchanges and joint utilization of microgravity facilities of both sides for programs proposed jointly by Japanese and US investigators will be reviewed on a case-by-case basis by the MCCG subsequent to acceptance of the proposal via peer review in each country; any specific cooperative activities recommended by the MCCG will be implemented through specific agreements negotiated between NASA and NEDO. As regards this solicitation (NRA), US proposers may include such cooperative activity as part of their proposal; however, such collaboration will cause approval of the proposal to be dependent not only on the normal NASA peer review process, but also on approval of the Japanese proposal through their peer review process and joint approval of the combined proposal by the MCCG. For further information/clarification, potential proposers should contact Dr. Merrill K. King at (202) 358-0817.

VIII. EVALUATION AND SELECTION

A. EVALUATION FACTORS AND PEER REVIEW PROCESS

The evaluation process for this NRA will begin with a scientific and technical peer review of the submitted proposals. NASA will also conduct an internal engineering review of the potential hardware requirements for proposals that include flight experiments. The programmatic objectives of this NRA, as discussed in the introduction to this Appendix, will be applied by NASA to enhance program breadth, balance, and diversity. NASA will also evaluate the cost of the proposal. Upon completion of deliberations, offerors will be notified regarding proposal selection or rejection. Offerors whose proposals are declined will have the opportunity of a verbal debriefing with a NASA representative regarding the reasons for this decision. Additional information on the evaluation and selection process is given in Appendix C.

This paragraph replaces Section 13 of Appendix C. The principal elements considered in the evaluation of proposals solicited by this NRA are: relevance to NASA's objectives (See Page A-11), intrinsic merit, and cost. Of these, intrinsic merit has the greatest weight, followed by relevance to NASA's objectives, of slightly lesser weight. Both of these elements have greater weight than cost. Evaluation of the intrinsic merit of the proposal includes consideration of the following factors, in descending order of importance:

1. Overall scientific or technical merit, including evidence of unique or innovative methods, approaches, or concepts, and the potential for new discoveries or understanding;

2. Demonstration of the need for microgravity conditions for the proposed effort, with explanation of how the microgravity environment will aid in elucidation of combustion phenomena;

3. Qualifications, capabilities, and experience of the proposed principal investigator, team leader, or key personnel who are critical in achieving the proposal objectives;

4. Institutional resources and experience that are critical in achieving the proposal objectives;

5. Overall standing among similar proposals available for evaluation and/or evaluation against the known state-of-the-art.

Evaluation of the cost of a proposed effort includes consideration of the realism and reasonableness of the proposed cost, and the relationship of the proposed cost to available funds.

The MSAD Director will make the final selection based on science panel and programmatic recommendations. Upon completion of all deliberations, a selection statement will be released notifying each proposer of proposal selection or rejection. Offerers whose proposals are declined will have the opportunity of a verbal debriefing regarding the reasons for this decision.

B. SELECTION CATEGORIES, PERIOD OF SUPPORT, AND FLIGHT DEFINITION PROCESS

Proposals selected for support through this NRA will be selected as either ground-based or flight definition investigations. Investigators offered support in the ground-based program normally will be required to submit a new proposal for competitive renewal after no more than four years of support. Investigators offered flight definition status are expected to begin preparing detailed experiment requirements and concepts for flight development shortly after selection in cooperation with the assigned representative from a NASA Center. The selected investigations will be required to comply with MSAD policies, including the return of all appropriate information for inclusion in the MSAD archives during the performance of and at the completion of the contract or grant.

Commitment by NASA to proceed from flight definition to the execution of a flight experiment will be made only after several additional engineering and scientific reviews and project milestones have established

the feasibility and merit of the proposed experiment. Investigations that do not pass these reviews will be funded for a limited period (approximately one year) to allow an orderly termination of the project.

The Principal Investigator in flight definition must prepare a Science Requirements Document (SRD) early in the development of a flight experiment to guide the design, engineering, and integration effort for the instrument. The SRD describes specific experiment parameters, conditions, background, and justification for flight. Ground-based, normal, and reduced-gravity experimentation, as well as any necessary parallel modeling efforts, may also be required to prepare an adequate Science Requirements Document. The amount of support (technical, scientific, and budgetary) provided to investigators by NASA will be determined based upon specific investigator needs and the availability of resources to NASA and MSAD.

It should be noted that while a proposer can propose multiple flights, in general NASA will not commit to more than one flight without a reflight review after the first flight.

IX. BIBLIOGRAPHY

Background materials are available to NRA proposers upon written request to:

Mr. Thomas H. Acquaviva
Mail Stop 500-115
Lewis Research Center
National Aeronautics and
Space Administration
Cleveland, OH 44135
Telephone: (216) 433-8020
Telefax: (216) 433-8660

Documents that may provide useful information to proposers are listed below:

- Microgravity Science & Applications Program Tasks and Bibliography for FY1994. NASA Technical Memorandum 4677, March 1995.
- Microgravity Combustion Science: Progress, Plans, and Opportunities, NASA Technical Memorandum 105410, April 1992.
- Proceedings of the Second International Microgravity Combustion Workshop September 15-17, 1992.
- Proceedings of the Third International Microgravity Combustion Conference, April 11-13,1995.
- STS Investigators' Guide, NASA Marshall Space Flight Center

BLANK PAGE

HARDWARE AND FACILITY DESCRIPTIONS

MICROGRAVITY COMBUSTION SCIENCE: RESEARCH AND FLIGHT DEVELOPMENT OPPORTUNITIES

The Microgravity Science and Applications Division (MSAD) is pursuing a program for the development of Space Shuttle and early International Space Station (ISS) payloads that can be configured (or reconfigured) to accommodate multiple users. This evolutionary program is expected to meet the science requirements of increasingly sophisticated microgravity investigations and to permit the eventual development of experiment payload technologies for research throughout the era of the ISS.

I. FLIGHT HARDWARE

The experimental apparatus described in this section are under development for flight on a series of Space Shuttle missions and/or ISS. NASA anticipates several additional future flight opportunities for investigations capable of using this hardware. Minor modifications of the current hardware may be possible to make it more versatile and to accommodate users and experiments other than those for which it was originally designed. Several potential enhancements are highlighted in the descriptions for the current hardware. Availability of the instruments described here, with or without modification, is contingent upon the availability and allocation of resources, and cannot be guaranteed at this time.

More detailed descriptions of the current flight hardware may be requested in the Letter of Intent described in Appendix A, Section IV.

A. COMBUSTION MODULE

The Space Station Combustion Module is part of the Space Station Fluids/Combustion Facility. The SS FCF is a three-rack facility with a rack which contains the hardware required to support fluid physics and dynamics experiments, a rack which contains the hardware required to support combustion experiments and another rack located between the first two which provides core functions and system control. The hardware in the combustion rack falls into three groups: core systems, combustion module, and experiment specific.

1. Core System Capabilities/Description

The core systems are the primary interface to space station systems and the crew. The core systems also provide space for, interfaces to, and control of the combustion module and experiment specific hardware. Following is a description of the various functions performed by the core systems.

Structural Support The core systems provide structural support for all of the core systems packages and the Combustion Module hardware. This support is accomplished through the use of International Standard Payload Racks (ISPR's) which mount directly into the space station U.S. Laboratory Module.

Facility Command, Control and Data Handling Facility command, control and data handling (CCDH) will be accomplished by implementing a distributed control, Versa Module Europe (VME) bus system architecture. One VME bus system will be located in the core rack to provide facility level CCDH and one will be located in the combustion rack to provide CCDH to the hardware located in that rack. A Fiber Distributed Data Interface (FDDI) system is planned for inter-rack communications due to the high data rates required. The CCDH has three interfaces with space station: a Mil-1553 B data bus, an Ethernet data

21

bus, and a fiber optic high rate data bus. Data, including digitized and compressed video, will be stored in high volume mass storage devices until it can be downlinked to the ground.

Crew Interface The crew interface will provide a system for the crew to view sensor and video data and control the facility. This system will include a video monitor and a laptop computer.

Video Image Control and Processing Core systems will provide for routing and processing of video images generated by the facility. A dedicated VME card cage will be used to provide this control, and digitization and compression of images so that the images can be stored. (Digitization and compression of images is required so the data can be stored on a reasonably sized storage device and sent to the ground within a reasonable time.)

Electrical Power Core systems will provide for conditioning, conversion and distribution of 120 VDC power provided by space station. The core rack will provide for 28 VDC and 120 VDC to the combustion rack and the combustion rack will additionally provide 5 VDC and 12 VDC.

Thermal Control Core systems will reject heat from the facility via an interface with the space station moderate temperature water system. Both the core and fluids racks will have an avionics air system tied into the water systems to provide general surface cooling. In addition, the core rack will contain heat exchanger/pump assemblies to route cooled water to specific hardware in the facility that requires large amounts of cooling.

Vibration Data Processing A Space Acceleration Measurement System II (SAMS II) Remote Triaxial Sensor Electronics Enclosure (RTS-EE) will be located in the core rack to provide data processing and measurement support for the sensor head that will be located in the combustion module.

2. Combustion Module Capabilities/Description

The combustion module consists of an experiment package, a fluid supply package and an exhaust/vent package. Each of these packages, along with portions of each, will be capable of being replaced on orbit in order to upgrade and/or provide additional functionality.

Experiment Package The experiment package is the primary element of the combustion module. It is comprised of two major elements, the combustion chamber and the diagnostics mounted around the chamber. The combustion chamber is cylindrical with domed heads, has approximately 80 liters internal free volume and has a maximum design pressure of 1000 kPA. A number of window ports provide optical access to the interior of the chamber. The windows in these ports are designed to be replaceable on orbit so that they can be tailored to the diagnostic technique using the window. An instrumentation ring and slide rails provide a standard set of interfaces inside the chamber. An Experiment Mounting Structure (EMS), which is unique to the particular science investigation being conducted, mounts within the chamber on these slide rails and interfaces to the instrumentation ring for gases, power, command, control and data. One end dome of the combustion chamber will be opened on orbit for access to the inside of the chamber and installation of EMSs. A glovebox can be provided which interfaces with the chamber, if required, to maintain containment of materials within the chamber while the dome is open.

There are three types of diagnostics mounted around the chamber: optical, chemical, and sensor. The optical diagnostics are mounted on an optical plate that allows for reconfiguration on orbit, and the combustion event is viewed through windows in the combustion chamber. These windows are of various size and are chosen to be optically compatible with the diagnostic tool which will utilize that viewport. The chemical diagnostics consist of a gas chromatograph used to sample the contents of the combustion chamber to determine the products of combustion. The sensor diagnostics provide information such as chamber pressure, chamber wall temperature, and temperatures of gases flowing into the chamber. A SAMS II sensor head will also be mounted near the chamber to measure the vibration disturbances during test runs.

The standard optical diagnostics planned for the facility are two orthogonal intensified black and white video cameras, two orthogonal standard color video cameras, soot volume fraction measurements and

22

soot temperature measurements. Filters and lenses can be changed to provide a variety of field of views and resolution combinations for selected experiments. Some of the other diagnostics that are being studied to determine if they can be accommodated are color schlieren imaging, infrared imaging, ultraviolet intensified imaging, color intensified imaging, infrared intensified imaging, laser doppler velocimetry, and both gas and liquid phase particle imaging velocimetry.

Fluid Supply Package The fluid supply package provides all gaseous fuels, diluent and oxygen required to perform the envelope combustion experiments. The package consists of gas storage and gas flow control functions. Pure gases and nominal mixtures will be stored in bottles at pressures up to 20 MPa. Some of the gases will be stored as pressurized liquids. The combustion module will utilize nitrogen provided by the space station. The storage bottles will be designed to be easily changed out on-orbit, for resupply, with filled ones that have been brought to the space station. The flow control will allow for conversion of any liquefied fuels or diluents back to a gaseous state, mixing of gases to the concentrations required, filling of the combustion chamber to prescribed pressures, flowing of gases into the combustion chamber during combustion and venting or purging of the fluid systems and chamber. In addition the system will provide any controls of the gases required to assure the safety of the FCF and crew.

Exhaust/Vent Package The exhaust/vent package is the interface from the experiment and fluid supply packages to the space station vent system and allows the fluid system and combustion chamber to be evacuated. The primary function of this package is to process the gases being vented so they meet the interface requirements of space station. The package includes a recirculation loop and a vent path. The recirculation loop will convert post-combustion gases into species that are acceptable to vent, remove water from the gas, and filter particles out of the gas by circulating the gases from the combustion chamber through processing canisters and back into the chamber until the bulk gas in the chamber is acceptable for venting through the space station vent system.

The current concept for these packages is that they can accommodate the entire science envelope. If however, it is determined that the package needs to be upgraded or modified, it will be able to be removed from the rack and replaced.

3. Experiment Specific Hardware

The combustion module provides an empty combustion chamber with standard interfaces and a set of standard diagnostics mounted around the chamber. As experiments are identified for use in the FCF, additional hardware will be required to fully implement the science. Each experiment will need an EMS to mount within the combustion chamber and interface to the chamber. These EMS's may include hardware to ignite the fuel, hardware to deploy droplets, radiometers, thermistors, fuel holders, nozzles or trays, liquid fuel supplies or solid fuels, soot sampling mechanisms, hardware to seed gas or liquid phases for imaging purposes, or a pressure vessel in which to perform higher pressure combustion, such as for metals. At this time, two experiments, Structure of Flame Balls at Low Lewis Numbers (SOFBALL) and Laminar Soot Processes (LSP), are being designed to utilize the Combustion Module.

Some investigations may require specific optical diagnostics that are not provided by the facility. The optical plate that surrounds the combustion chamber will have the capability to be reconfigured to support new types of optical diagnostics and the chamber windows, as mentioned above, will be replaced as needed.

4. Software

The SS FCF project will provide the majority of the software required. This software will reside on the VME bus systems, except in two cases. If there are specific control algorithms/software required that have been developed by the specific science investigation team which can be integrated with the facility software, these could be loaded into the VME bus system in the combustion rack; or if a controller is included in the experiment specific hardware, then the specific science investigation team would be responsible for software that would reside on the controller.

B. MICROGRAVITY SMOLDERING COMBUSTION FLIGHT HARDWARE

The MSC experiment hardware is a Get Away Special Canister (GASCAN) payload. The payload is flown in the Shuttle cargo bay. The hardware design consists of two modules, a combustion module and an electronics module. The combustion module is comprised of two sealed chambers and a flow system. Each chamber provides the environment and hardware to conduct a combustion test. The chamber is designed for atmospheric test conditions with allowable pressure increase to three atmospheres. The chambers are semicircular cylinders that have a free volume of 20 liters and measure approximately 29 cm high with a 22 cm radius. Each chamber is presently instrumented for measurement of interior pressure, chamber wall temperature (2), chamber gas temperature (4) and fuel sample temperatures (12) and has a window for photographic recording of the combustion process. Interior lighting is provided to illuminate the fuel sample for the photographic recording.

The flow system associated with the combustion chamber provides a constant mass flow to the fuel sample. It consists of a pressurized oxidizer tank, pressure regulator, solenoid isolation valves, flow restriction orifice and pressure transducers (2). The system is designed to provide a preselected flow of 0.5 to 2.0 mm/sec through a 120 mm diameter tube. The hardware currently provides 1.0 mm/sec flow for 48 minutes nominal. The electronics module provides for all the experiment power, control, and data acquisition. It consists of a battery assembly (silver zinc cells), data acquisition box (STD bus motherboard and printed circuit boards), power control unit, igniter power unit, video cameras (2) and video tape recorders (2). The power system has the capacity of 620 watt-hours on the nominal 28 volt DC battery.

The data acquisition system provides 12 bit resolution of 48 instrumentation channels and provides digital data storage of 512 kilobytes for pressure, temperature, and housekeeping data.

The experiment is automatically controlled via on-board software with no current downlink capability. The electronics design is capable of active control of the ignition and flow functions as well as data acquisition and imaging control. Each video camera and recorder have a two hour recording capacity.

C. SOLID SURFACE COMBUSTION EXPERIMENT HARDWARE

The Solid Surface Combustion Experiment (SSCE) hardware is a Shuttle Middeck payload. The hardware utilizes the volume of four Middeck lockers and consists of a combustion chamber, a lead acid battery , a data acquisition and control assembly, 16mm movie cameras (2) and support structure. The combustion chamber provides a sealed environment for a combustion test. It is designed for test conditions up to 2 atmospheres pressure and provides approximately 38 liters volume. The chamber is a cylinder with two elliptical end domes and has a dimension of 50 cm internal length with an internal diameter of 34 cm. The chamber has two orthogonal windows for combustion process photographic recording and is equipped with instrumentation for measuring the chamber temperature, chamber pressure and fuel/combustion temperatures (6). The chamber itself occupies the space of two Middeck lockers.

The remaining hardware is mounted to a baseplate that also occupies the space of two Middeck lockers. This hardware provides for all the power, control and data acquisition of the experiment. The power is provided by a 14 cell lead acid battery that provides 72 watt-hours at 28 volt DC. The power distribution and electronic data acquisition is provided by an electrical box that houses DC/DC converters (5 V, 12 V DC), an STD bus motherboard and printed circuit boards. The data acquisition system provides 12 bit resolution and digital data storage of 256 kilobytes.

Photographic recording of the combustion process is provided by two 16mm movie cameras equipped with 200 foot film magazines. The cameras operate at 24 , 48, 64, 100, 150 or 200 frames per second.

The experiment as currently designed is automated (software controlled) and only utilizes the available crew to configure the hardware and activate the experiment.

D. TRANSITIONAL/TURBULENT GAS JET DIFFUSION FLAMES HARDWARE

The TGDF experiment involves study of a diffusion flame in the absence of buoyant-driven convection flows. The main focus of the diffusion flames experiment is the definition of effects of externally applied large scale structures in a laminar flow gas jet (propane) flame. The study will provide data that can be correlated to the large scale structures observed in 1-g transitional and turbulent gas jet flames.

The experiment hardware is designed for operation during a Shuttle flight with the hardware accommodated within a 5 foot long Get Away Special Canister (GASCAN). The hardware consists of a combustion chamber, instrumentation, data acquisition, and power distribution and control electronics. The experiment operation accomplishes four test matrix points during a single flight.

The main component of the hardware is the combustion chamber. The 55 liter hermetically sealed combustion chamber provides a minimum 48 liters free volume. The chamber encloses the fuel system, ignition system, instrumentation and the disturbance mechanism. The power, recording and control of the experiment is provided by the electronics shelf which consists of a battery of lead acid cells, power control unit, data acquisition and control (DACS) units and video tape recorders.

The propane fuel system consists of a 75 cc fuel supply bottle, a pressure regulator, two solenoid isolation valves, a choked flow orifice and a fuel nozzle. A constant mass flow is established by regulating the supply bottle pressure to a constant pressure of about 3 atmospheres and establishing a choked flow through the orifice. The propane fuel is ignited by a retractable hot-wire igniter. An arm suspends a small spring-shaped Kanthol wire in the fuel jet. Electronics provide a constant current through the wire to provide the energy to produce a flame. The arm is them rotated out of the fuel jet by a rotary solenoid.

The flame disturbance is provided by an iris mechanism that is centered over the fuel nozzle. The iris is driven between a minimum circular opening and a maximum circular opening by a reciprocating arm which is driven by a stepper motor. The stepper motor with its associated control electronics allows the operation of the iris over the required 1 to 10 Hz frequency range.

Data recording includes flame and gas temperature measurements made with eight Type K (chromel-alumel) thermocouples located at different heights above the fuel nozzle and different radii from the fuel nozzle centerline. Chamber pressure measurement is provided by a pressure transducer mounted in the chamber wall. Radiation measurements are provided by three radiometers, two of which measure the radiation of a 5 mm slice of the flame (two different axial locations) while the third measures the radiation from the entire flame length. Two video cameras in conjunction with two 8 mm video tape recorders provide two image records of the flame. The data acquisition and control system (DACS) provides for the instrumentation signal processing through a 12-bit analog/digital electronics. The signals are sampled at 30 Hz and recorded in memory chips.

E. DROPLET COMBUSTION EXPERIMENT HARDWARE

The Droplet Combustion Apparatus (DCA) is a 6-locker SMIDEX payload experiment for studying the quasi-steady combustion and extinction of single pure hydrocarbon fuel droplets of diameter in the 1.5 to 5 mm range with a mixture of helium and oxygen at atmospheric or subatmospheric pressure. Other experiments and hardware not currently in the DCA design that may be of scientific value and of a nature close to the intent of the DCA hardware include:

1) Use of fuel mixtures
2) Computer-controlled test gas supply to vary environment during test

3) Computer-controlled thermal background radiator to study radiation effects on the combustion processes

4) Computer-controlled extended range ignition system to ignite more difficult substances

5) Radiometer for flame zone temperature measurement

6) Schlieren system for photographing gas flows

7) High speed, high resolution video photography of disruption events

8) Thermophoretic soot sampling

9) Multiple droplet deployment device

Currently, the experiment features an opposed-needle deployment device to grow, stretch, deploy (at residual velocities below 1 mm/s) and ignite a droplet using a spark or hot wire technique. The DCA test chamber is a sealed container of 30 liter free gas volume. The droplet itself is photographed by a 35 mm film camera operating at 80 fps with a 3 cm field of view, a 3 cm total depth of field and a 40 micron resolution. The flame is imaged using a CCD UV intensified array camera with an OH emission line filter. This camera is operated at 30 fps with a 4 cm field of view and 4 cm total depth of field with a minimum resolution of 200 microns. The experiment has semi-automatic menu-driven control electronics and a crew view port. Test chamber pressure and average temperature are monitored. A gas handling system allows the systematic addition of new gas to the chamber and allows for the mixing and scrubbing of previous test gas environments. The experiment will be operated in conjunction with an acceleration measurement unit to determine the residual gravitational levels.

F. MIDDECK GLOVEBOX

The Middeck Glovebox (MGBX) facility is an enclosed volume that provides physical isolation of various small-scale experiments from the middeck and enables crew member manipulation of these experiments through gloveports. The MGBX provides containment of powders, splinters, liquids, flames, or combustion products which may be produced from experiment operations. The MGBX occupies two standard lockers in the space shuttle middeck. the MGBX door opening to insert or retrieve experiment hardware is about 20.3 cm by 19.4 cm. The working volume is about 35 liters and is approximately 45 cm wide, 30 cm deep, and 25 cm high.

An air filtering system protects the middeck environment from experiment products. Forced air cooling can withdraw a maximum of 60 watts of experiment generated heat. Up to 60 watts of experiment power can be provided via a protected 28 Vdc line. A power converter box is also available which can provide +24Vdc, +5Vdc, +12Vdc, and -12Vdc lines.

The MGBX can be used in various modes of pressure and air circulation. The working area can serve as a sealed environment that is isolated from the crew cabin atmosphere, as a constantly recirculating atmosphere that is maintained at a pressure slightly lower than the middeck ambient, or as a working area open to the middeck. Airtight gloves or non-sealed cuffs are mounted in the two gloveports. Multipurpose filters remove particles, liquids, and reaction gases from the recirculated air. Pressure, humidity, and temperature sensors are utilized to monitor filter performance.

Video and 35 mm cameras are the primary method utilized for gathering data. The MGBX has three CCD video cameras. The camera control electronics are contained within the MGBX, while the camera heads can be mounted external to the MGBX and positioned to view through the specialized video ports, or through the large window on top of the MGBX. The videoports allow the camera heads to swivel to view the entire working area. Both black and white and color videocameras are available. Three video recorders provide data storage, with digital data stored in the audio channels (up to three audio and three discrete channels of data can be recorded). Due to limitations of the Space Shuttle middeck, there is no standard data or video downlink. There is the possibility of some near real-time video downlink (from the Shuttle Camcorder), but this will be determined on a mission-by-mission basis. Adjustable lighting, video

2b

port plugs, a backlight panel, a halogen flashlight, and a stray light window cover provide different photographic options.

The overall philosophy of the Glovebox program is to provide the ability to conduct smaller, less complex science experiments or technology demonstrations in a microgravity environment in a faster, better, and cheaper manner. The hardware development cycle runs approximately 2-3 years. At this time, 10 Glovebox Investigations in the disciplines of materials science, fluid physics, biotechnology, and combustion science are under development for flights on USML-2 in September 1995 and on USMP-3 in February 1996. The combustion science investigations include: Fiber Supported Droplet Combustion (FSDC), Comparative Soot Diagnostics (CSD), Forced Flow Flamespreading Test (FFFT), and Radiative Ignition and Transition to Spread Investigation (RITSI). The FFFT is also manifested on the Priroda Science Module launch to the Russian Mir Space Station in November 1995. This mission also includes a reflight of Candle Flames in Microgravity (CFM), which flew on USML-1. Future Glovebox flight opportunities include a Microgravity Science Laboratory-1 (MSL-1) Spacelab mission in March 1997, the Fourth United States Microgravity Payload Mission (USMP-4) in May 1997, and missions to the Russian Mir Space Station from March 1996 through November 1997.

G. ISS MICROGRAVITY SCIENCE GLOVEBOX

The Microgravity Science Glovebox (MSG) for the International Space Station (ISS) will be a larger version of the Middeck Glovebox. The MSG will have a larger work area to allow larger size and mass experiments to be conducted inside the Glovebox. The MSG will provide up to 1000 watts of experiment power, a vent connection, a nitrogen connection, an airlock, illumination, color and black and white video cameras and recorders for viewing, recording, or downlinking, and miscellaneous tools and cleaning supplies. It is envisioned that experiments will be conducted in the areas of fluid physics, combustion science, materials science, and biotechnology. The MSG will be developed by the European Space Agency and will be available for use soon after the deployment of the U.S. Laboratory Module of the ISS.

H. SOUNDING ROCKETS

Two microgravity combustion experiments, Spread Across Liquids (SAL) and Diffusive and Radiative Transport in Fires Experiment (DARTFire) are being flown as Sounding Rocket experiments, utilizing the Terrier-Black Brant as a carrier. (One SAL test was flown in November, 1994, with at least two more tests planned in 1995, while three DARTFire flights are planned for 1995 and 1996.) In the configuration being employed, these sounding rockets provide between six and seven minutes of quality microgravity time for up to about an 800 pound payload, which is fitted into two 22-inch diameter, 5-feet long test sections. In the Spread Across Liquids experiment, liquid fuel is loaded into a 30 cm long by 2 cm wide by 2.5 cm deep tray located inside a 10 cm by 10 cm cross-section flow duct used to provide a controlled low-speed air flow over the fuel surface. Hot wire igniters are located at each end of the tray to provide for multiple burns of the fuel in either direction relative to the imposed air flow. Thermocouples are placed at several locations in the fuel and surrounding gas. The sides of the fuel tray are constructed of schlieren-quality windows to allow viewing of the fuel from the side. In addition to standard thermocouple and pressure transducer instrumentation, the SAL experiment includes four color CCD cameras, two Particle Imaging Velocimetry systems for flow visualization, a rainbow schlieren system, and an infrared camera.

In the DARTFire experiment, in addition to numerous thermocouples, an intensified array camera with a rotating filter wheel, color and black and white video, and a spot radiometer for measurement of radiative heat loss from the flame and fuel surface are employed in the study of propagation of flame along a thermally thick solid fuel surface (black PMMA) with various levels of radiant energy flux being directed from an external source into the entire fuel surface, and with various velocities of gas flow of various compositions over the burning surface.

II. GROUND-BASED FACILITIES

Investigators often need to conduct reduced gravity experiments in ground-based facilities during the experiment definition and technology development phases. The NASA ground-based reduced gravity research facilities that support the MSAD combustion program include two drop towers at the Lewis Research Center (LeRC) and a DC-9 aircraft at LeRC. NASA data handling resources include wide-area network connectivity, supercomputing and directory services for NASA and non-NASA data holdings. Each of these facilities and resources has different capabilities and characteristics that should be considered by an investigator to determine which are best suited for conducting combustion science research.

A. 2.2-SECOND DROP TOWER

The 2.2-Second Drop Tower at LeRC provides 2.2 second of low-gravity test time for experiment packages consisting of up to 125 kilograms of hardware. The experiment package is enclosed in a drag shield and a gravitational acceleration of less than 10^{-5}g is obtained during the fall since the experiment package falls freely within the drag shield. The only external force acting on the falling experiment packages is the air drag associated with the relative motion of the package within the enclosure of the drag shield. At the end of a drop, the drag shield and the enclosed experiment are decelerated in a 2.2-meter deep sand pit by the deceleration spikes. The peak deceleration rate can be as high as 70g's. Eight to twelve tests can be performed in one day. Data from experiments are acquired by high speed motion picture cameras with rates up to 1,000 frames per second and by on-board data acquisition systems used to record data supplied by thermocouples, pressure transducers, and flow meters.

B. 5.18-SECOND ZERO-GRAVITY FACILITY

The 5.18-second Zero-Gravity at LeRC has a 132-meter free fall distance in a drop chamber which is evacuated by a series of pumpdown procedures to a final pressure of 1 Pa. Experiments utilizing hardware weighing up to 450 kilograms are mounted in a one-meter diameter by 3.4-meter high drop bus. Gravitational acceleration of less than 10^{-5}g is obtained. At the end of the drop, the bus is decelerated in a 6.1-meter deep container filled with small pellets of expanded polystyrene. The deceleration rate is typically 60g (for 20 millisec). Visual data is acquired through the use of high-speed motion picture cameras. Also, other data such as pressures, temperatures, and accelerations are either recorded on board with various data acquisition systems or are transmitted to a control room by a telemetry system capable of transmitting 18 channels of continuous data. Due to the complexity of drop chamber operations and time required for pump-down of the drop chamber, typically only one test is performed per day.

B. DC-9 AIRCRAFT

The DC-9 can provide up to 40 periods of low-gravity for 22 second intervals each during one flight. The aircraft accommodates a variety of experiments and is often used to refine spaceflight experiment equipment and techniques and to train crew members in experiment procedures, thus giving investigators and crew members valuable experience working in a weightless environment. Qualified observers or operators may fly with their experiment packages. The DC-9 obtains a low-gravity environment by flying a parabolic trajectory. Gravity levels twice those of normal gravity occur during the initial and final portions of the trajectory, while the brief pushover at the top of the parabola produces less than one percent of Earth's gravity (10^{-2} g). The interior DC-9 bay dimensions are 2.89 meters wide and 1.98 meters high by 16 meters long. Several experiments, including a combination of attached and free-floated hardware (which can provide effective gravity levels of nominally 10^{-3} g for periods up to 10 seconds) can be integrated in a single flight. The aircraft can supply a total of 80 amps of 28 volt dc, 90 amps of 115 volt ac 60Hz and 30 amps open each phase of 3 phase 115 volt ac 400 Hz. These are

maximum powers available to all users. Instrumentation and data collection capabilities must be contained in the experiment packages.

III. DIAGNOSTICS/MEASUREMENT CAPABILITY

NASA has adapted or developed a large number of diagnostic/measurement techniques for use in the Microgravity Combustion research program, with some of these techniques, including particle imaging velocimetry, laser light scattering, and Rainbow Schlieren Deflectometry having already been demonstrated in flight. A brief list of techniques, already in use or under development and possibly available for use in future programs appears below.

1. Soot Temperature Measurements Using Pyrometric Techniques
2. Rainbow Schlieren For Measurement of Temperature Distributions
3. Planar 2D Temperature and CH and OH Concentration Measurements Via Rayleigh Scattering and Laser-Induced Fluorescence
4. Light Sheet Flow Visualization and/or Velocimetry
5. Laser Doppler Velocimetry
6. Liquid Surfaces Temperature and Vapor Phase Concentration Measurements Via Exciplex Fluorescence
7. Determination of CH4, CO2, and H2O Concentrations Via Line Absorption Techniques
8. Planar Laser-Induced Fluorescence for Determination of Flame Front Position
9. Particle Imaging Velocimetry
10. Liquid Phase Thermometry and Fluorescence of Aromatics to Evaluate Droplet Surface Transport and Internal Flow
11. Diode Laser Wavelength Modulation Spectroscopy For Quantitative Molecular Oxygen Concentration Measurements
12. Compact Laser-Diode CCD Array for Measuring Instantaneous Radial Variations of the Temperature Fields Within a Burning Droplet and In the Gas-Phase Around It While Also Instantaneously Measuring Droplet Size and Regression Rate
13. Laser-Induced Incandescence for measurement of soot volume fractions

For further information on the state of development of these techniques for use in Microgravity Combustion research activities, please contact Dr. Paul Greenberg (NASA/Lewis Research Center) at 216-433-3621.

BLANK PAGE

INSTRUCTIONS FOR RESPONDING TO NASA RESEARCH ANNOUNCEMENTS FOR SOLICITED RESEARCH PROPOSALS

(August 1988)

1. FOREWORD

a. NASA depends upon industry, educational institutions, and other nonprofit organizations for most of its research efforts. While a number of mechanisms have been developed over the years to inform the research community of those areas in which NASA has special research interests, these instructions apply only to "NASA Research Announcements," a form of "broad agency announcement" described in 6.102(d)(2) and 35.016 of the Federal Acquisition Regulation (FAR). The "NASA Research Announcement (NRA)" permits competitive selection of research projects in accordance with statute while at the same time preserving the traditional concepts and understandings associated with NASA sponsorship of research.

b. These instructions are Appendix I to 18-70.203 of the NASA Federal Acquisition Regulation Supplement.

2. POLICY

a. NASA fosters and encourages the submission of research proposals relevant to agency mission requirements by solicitations, "NASA Research Announcements," which describe research areas of interest to NASA. Proposals received in response to an NRA will be used only for evaluation purposes.

b. NASA does not allow a proposal, the contents of which are not available without restriction from another source, or any unique ideas submitted in response to an NRA to be used as the basis of a solicitation or in negotiation with other organizations, nor is a pre-award synopsis published for individual proposals.

c. A solicited proposal that results in a NASA award becomes part of the record of that transaction and may be available to the public on specific request; however, information or material that NASA and the awardee mutually agree to be of a privileged nature will be held in confidence to the extent permitted by law, including the Freedom of Information Act.

3. PURPOSE

These instructions are intended to supplement documents identified as "NASA Research Announcements." The NRA's contain programmatic information and certain "NRA-specific" requirements that apply only to proposals prepared in response to that particular announcement. These instructions contain the general proposal preparation information which applies to responses to all NRA's.

4. RELATIONSHIP TO AWARD

a. A contract, grant, cooperative agreement, or other agreement may be used to accomplish an effort funded on the basis of a proposal submitted in response to an NRA. NASA does not have separate "grant proposal" and "contract proposal" categories, so all proposals may be prepared in a similar fashion. NASA will determine the appropriate instrument.

b. Grants are generally used to fund basic research in educational and nonprofit institutions, while research in other private sector organizations is accomplished under contract. Additional information peculiar to the contractual process (certifications, cost and pricing data, facilities information, etc.) will be requested, as necessary, as the procurement progresses. Contracts resulting from NRA's are subject to the Federal Acquisition Regulation and the NASA FAR Supplement (NHB 5100.4). Any resultant grants or cooperative agreements will be awarded and administered in accordance with the NASA Grant and Cooperative Agreement Handbook (NHB 5800. 1).

5. CONFORMANCE TO GUIDANCE

a. NASA does not have any mandatory forms or formats for preparation of responses to NRA's; however, it is requested that proposals conform to the procedural and submission guidelines covered in these instructions. In particular, NASA may accept proposals without discussion; hence, proposals should initially be as complete as possible and be submitted on the proposers' most favorable terms.

b. In order to be considered responsive to the solicitation, a submission must, at a minimum, present a specific project within the areas delineated by the NRA; contain sufficient technical and cost information to permit a meaningful evaluation; be signed by an official authorized to legally bind the submitting organization; not merely offer to perform standard services or to just provide computer facilities or services; and not significantly duplicate a more specific current or pending NASA solicitation. NASA reserves the right to reject any or all proposals received in response to an NRA when such action is considered in the best interest of the Government.

6. NRA-SPECIFIC ITEMS

a. Several proposal submission items will appear in the NRA itself. These include: the unique NRA identifier; when to submit proposals; where to send proposals; number of copies required; and sources for more information.

b. Items included in these instructions may be supplemented by the NRA, as circumstances warrant. Examples are: technical points for special emphasis; additional evaluation factors; and proposal length.

7. PROPOSAL CONTENTS

a. The following general information is needed in all proposals in order to permit consideration in an objective manner. NRA's will generally specify topics for which additional information or greater detail is desirable. Each proposal copy shall contain all submitted material, including a copy of the transmittal letter if it contains substantive information.

b. Transmittal Letter or Prefatory Material

(1) The legal name and address of the organization and specific division or campus identification if part of a larger organization;

(2) A brief, scientifically valid project title intelligible to a scientifically literate reader and suitable for use in the public press;

(3) Type of organization e.g., profit, nonprofit, educational, small business, minority, women-owned, etc.;

(4) Name and telephone number of the principal investigator and business personnel who may be contacted during evaluation or negotiation;

(5) Identification of any other organizations that are currently evaluating a proposal for the same efforts;

(6) Identification of the specific NRA, by number and title, to which the proposal is responding;

(7) Dollar amount requested of NASA, desired starting date, and duration of project;

(8) Date of submission; and

(9) Signature of a responsible official or authorized representative of the organization, or any other person authorized to legally bind the organization (unless the signature appears on the proposal itself).

c. Restriction on Use and Disclosure of Proposal Information

It is NASA policy to use information contained in proposals for evaluation purposes only. While this policy does not require that the proposal bear a restrictive notice, offerers or quoters should, in order to maximize protection of trade secrets or other information that is commercial or financial and confidential or privileged, place the following notice on the title page of the proposal and specify the information subject to the notice by inserting appropriate identification, such as page numbers, in the notice. In any event, information (data) contained in proposals will be protected to the extent permitted by law, but NASA assumes no liability for use and disclosure of information not made subject to the notice.

NOTICE — Restriction on Use and Disclosure of Proposal Information

The information (data) contained in [insert page numbers or other identification] of this proposal constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offerer, be used or disclosed other than for evaluation purposes; provided, however, that in the event a contract (or other agreement) is awarded on the basis of this proposal the Government shall have the right to use and disclose this information (data) to the extent provided in the contract (or other agreement). This restriction does not limit the Government's right to use or disclose this information (data) if obtained from another source without restriction.

d. **Abstract**

Include a concise (200-300 word, if not otherwise specified in the NRA) abstract describing the objective of the proposed effort and the method of approach.

e. **Project Description**

(1) The main body of the proposal shall be a detailed statement of the work to be undertaken and should include objectives and expected significance; relation to the present state of knowledge in the field; and relation to previous work done on the project and to related work in progress elsewhere. The statement should outline the general plan of work, including the broad design of experiments to be undertaken and an adequate description of experimental methods and procedures. The project description should be prepared in a manner that addresses the evaluation factors in these instructions and any additional specific factors in the NRA. Any substantial collaboration with individuals not referred to in the budget or use of consultants should be described. Note, however, that subcontracting significant portions of a research project is discouraged.

(2) When it is expected that the effort will require more than one year for completion, the proposal should cover the complete project to the extent that it can be reasonably anticipated. Principal emphasis should, of course, be on the first year of work, and the description should distinguish clearly between the first year's work and work planned for subsequent years.

f. **Management Approach**

For large or complex efforts involving interactions among numerous individuals or other organizations, plans for distribution of responsibilities and any necessary arrangements for ensuring a coordinated effort should be described. Aspects of any required intensive working relations with NASA field centers that are not logical inclusions elsewhere in the proposal should be described in this section.

g. **Personnel**

The principal investigator is responsible for direct supervision of the work and participates in the conduct of the research regardless of whether or not compensation is received under the award. A short biographical sketch of the principal investigator, a list of principal publications and any exceptional qualifications should be included. Omit social security number and other personal items which do not merit consideration in evaluation of the proposal. Give similar biographical information on other senior professional personnel who will be directly associated with the project. Give the names and titles of any other scientists and technical personnel associated substantially with the project in an advisory capacity. Universities should list the approximate number of students or other assistants, together with information as to their level of academic attainment. Any special industry-university cooperative arrangements should be described.

h. **Facilities and Equipment**

(1) Describe available facilities and major items of equipment especially adapted or suited to the proposed project, and any additional major equipment that will be required. Identify any government-owned facilities, industrial plant equipment, or special tooling that are proposed for use on the project.

(2) Before requesting a major item of capital equipment, the proposer should determine if sharing or loan of equipment already within the organization is a feasible alternative to purchase. Where such arrangements cannot be made, the proposal should

so state. The need for items that typically can be used for both research and non-research purposes should be explained.

i. **Proposed Costs**

(1) Proposals should contain cost and technical parts in one volume: do not use separate "confidential" salary pages. As applicable, include separate cost estimates for salaries and wages; fringe benefits; equipment; expendable materials and supplies; services; domestic and foreign travel; ADP expenses; publication or page charges; miscellaneous identifiable direct costs; and indirect costs. List salaries and wages in appropriate organizational categories (e.g., principal investigator, other scientific and engineering professionals, graduate students, research assistants, and technicians and other non-professional personnel). Estimate all manpower data in terms of man-months or fractions of full-time.

(2) Explanatory notes should accompany the cost proposal to provide identification and estimated cost of major capital equipment items to be acquired; purpose and estimated number and lengths of trips planned; basis for indirect cost computation (including date of most recent negotiation and cognizant agency); and clarification of other items in the cost proposal that are not self-evident. List estimated expenses as yearly requirements by major work phases. (Standard Form 1411 may be used).

(3) Allowable costs are governed by FAR Part 31 and the NASA FAR Supplement Part 18-31 (and OMB Circulars A-21 for educational institutions and A-122 for nonprofit organizations).

j. **Security**

Proposals should not contain security classified material. However, if the proposed research requires access to or may generate security classified information, the submitter will be required to comply with applicable Government security regulations.

For other current projects being conducted by the principal investigator, provide title of project, sponsoring agency, and ending date.

k. **Special Matters**

(1) Include any required statements of environmental impact of the research, human subject or animal care provisions, conflict of interest, or on such other topics as may be required by the nature of the effort and current statutes, executive orders, or other current Government-wide guidelines.

(2) Proposers should include a brief description of the organization, its facilities, and previous work experience in the field of the proposal. Identify the cognizant Government audit agency, inspection agency, and administrative contracting officer, when applicable.

8. RENEWAL PROPOSALS

a. Renewal proposals for existing awards will be considered in the same manner as proposals for new endeavors. It is not necessary that a renewal proposal repeat all of the information that was in the original proposal upon which the current support was based. The renewal proposal should refer to its predecessor, update the parts that are no longer current, and indicate what elements of the proposal are expected to be covered during the period for which extended support is desired. A description of any significant findings since the most recent progress report should be included. The renewal proposal should treat, in reasonable detail, the plans for the next period, contain a cost estimate, and otherwise adhere to these instructions.

b. NASA reserves the right to renew an effort either through amendment of an existing contract or by a new award.

9. LENGTH

Unless otherwise specified in the NRA, every effort should be made to keep proposals as brief as possible, concentrating on substantive material essential for a complete understanding of the project. Experience shows that few proposals need exceed 15-20 pages. Any necessary detailed information, such as reprints, should be included as attachments rather than in the main body of the proposal. A complete set of attachments is necessary for each copy of the proposal. As proposals are not returned, avoid use of "one-of-a-kind"

attachments: their availability may be mentioned in the proposal.

10. JOINT PROPOSALS

a. Some projects involve joint efforts among individuals in different organizations or mutual efforts of more than one organization. Where multiple organizations are involved, the proposal may be submitted by only one of them. In this event, it should clearly describe the role to be played by the other organizations and indicate the legal and managerial arrangements contemplated. In other instances, simultaneous submission of related proposals from each organization might be appropriate, in which case parallel awards would be made.

b. Where a project of a cooperative nature with NASA is contemplated, the proposal should describe the contributions expected from any participating NASA investigator and agency facilities or equipment which may be required. However, the proposal must be confined only to that which the proposing organization can commit itself. "Joint" proposals which purport to specify the internal arrangements NASA will actually make are not acceptable as a means of establishing an agency commitment.

11. LATE PROPOSALS

A proposal or modification thereto received after the date or dates specified in an NRA may still be considered if the selecting official deems it to offer NASA a significant technical advantage or cost reduction.

12. WITHDRAWAL

Proposals may be withdrawn by the proposer at any time. Offerers are requested to notify NASA if the proposal is funded by another organization or of other changed circumstances which dictate termination of evaluation.

13. EVALUATION FACTORS

a. Unless otherwise specified in the NRA, the principal elements (of approximately equal weight) considered in evaluating a proposal are its relevance to NASA's objectives, intrinsic merit, and cost.

b. Evaluation of a proposal's relevance to NASA's objectives includes the consideration of the potential contribution of the effort to NASA's mission.

c. Evaluation of its intrinsic merit includes the consideration of the following factors, none of which is more important than any other:

(1) Overall scientific or technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal.

(2) The offerers capabilities, related experience, facilities, techniques, or unique combinations of these which are integral factors for achieving the proposal objectives.

(3) The qualifications, capabilities, and experience of the proposed principal investigator, team leader, or key personnel who are critical in achieving the proposal objectives.

(4) Overall standing among similar proposals available for evaluation and/or evaluation against the known state-of-the-art.

d. Evaluation of the cost of a proposed effort includes the consideration of the realism and reasonableness of the proposed cost and the relationship of the proposed cost to available funds.

14. EVALUATION TECHNIQUES

Selection decisions will be made following peer and/or scientific review of the proposals. Several evaluation techniques are regularly used within NASA. In all cases, however, proposals are subject to scientific review by discipline specialists in the area of the proposal. Some proposals are reviewed entirely in-house where NASA has particular competence; others are evaluated by a combination of in-house people and selected external reviewers, while yet others are subject to the full external peer review technique (with due regard for conflict-of-interest and protection of proposal information), such as by mail or through assembled panels. Regardless of the technique, the final decisions are always made by a designated NASA selecting official. A proposal which is scientifically and programmatically meritorious, but which is not selected for award during its initial review under the NRA may be included in subsequent reviews unless the proposer requests otherwise.

15. SELECTION FOR AWARD

a. When a proposal is not selected for award, and the proposer has indicated that the proposal is not to be held over for subsequent reviews, the proposer will be notified that the proposal was not selected for award. NASA will notify the proposer and explain generally why the proposal was not selected. Proposers desiring additional information may contact the selecting official who will arrange a debriefing.

b. When a proposal is selected for award, negotiation and award will be handled by the procurement office in the funding installation. The proposal is used as the basis for negotiation with the submitter. Formal RFP's are not used to obtain additional information on a proposal selected under the NRA process. However, the contracting officer may request certain business data and may forward a model contract and other information which will be of use during the contract negotiation.

16. CANCELLATION OF NRA

NASA reserves the right to make no awards under this NRA and, in the absence of program funding or for any other reason, to cancel this NRA by having a notice published in the Commerce Business Daily. NASA assumes no liability for canceling the NRA or for anyone's failure to receive actual notice of cancellation. Cancellation may be followed by issuance and synopsis of a revised NRA, since amendment of an NRA is normally not permitted.

NASA RESEARCH ANNOUNCEMENT (NRA) SCHEDULE

MICROGRAVITY COMBUSTION SCIENCE: RESEARCH AND FLIGHT EXPERIMENT OPPORTUNITIES

All proposals submitted in response to this Announcement are due on the date and at the address given below by the close of business (4:30 PM EST). NASA reserves the right to consider proposals received after this deadline if such action is judged to be in the interest of the U.S. Government. A complete schedule of the review of the proposals is given below:

NRA Release Date: .... May 26, 1995

Letter of Intent Due: .... July 10, 1995

Proposal Due: .... August 25, 1995

Proposals that are mailed through the U.S. Postal Service by express, first class, registered, or certified mail are to be sent to NASA Headquarters, addressed as follows:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
Washington, DC 20546-0001

Proposals sent by commercial delivery or courier services (e.g. Federal Express) are to be delivered to the following address between the hours of 8 AM and 4:30 PM:

Dr. Merrill K. King
Microgravity Science and Applications Division
Code UG
National Aeronautics and Space Administration
ATTN: Receiving and Inspection (Rear of building)
300 E Street, SW
Washington, DC 20024-3210

NASA cannot receive proposals on Saturdays, Sundays, or Federal holidays.

Final Selections: .... January, 1996

Funding commences: March,1996
(dependent upon procurement process)

BLANK PAGE

NASA Research Announcement (NRA)/Announcement of Opportunity (AO) Mailing List Update

This is the update form for the NASA Office of Life & Microgravity Sciences & Applications (OLMSA) NRA/AO mailing list. Please fill out ***CONTACT INFORMATION*** *completely. Check only those that apply in* **Institution Type** *and* **Discipline**. ***Fold the form, secure with tape, and mail it back to the address on the reverse side. Proper postage must be applied.***

Please check which announcements you would like to receive:

- ☐ 1. NASA Research Announcements (basic, non-flight, on-going research)
- ☐ 2. Announcements of Opportunity (specific space flight mission)

Check one:

- ☐ 1. Please ***add*** my name to the mailing list
- ☐ 2. Please ***remove*** my name from the mailing list (please attach mailing label)
- ☐ 3. Please ***change*** my current listing (please attach mailing label)
- ☐ 4. Please leave my current listing ***unchanged***

CONTACT INFORMATION . If your address has changed or your mailing label is incorrect, please provide COMPLETE contact information.

Address Number: (obtain from mailing label)

Salutation (Mr., Mrs., Ms., Dr., Prof., etc.)

Suffix (Ret., PhD., Jr., III, etc.)

First Name:

MI:

Last:

Organization:

Division/Department:

Street:

City:

State:

Zip Code:

Telephone No:

Fax No:

Country: (foreign addresses, please specify)

Institution Type

(check only those that apply)

- ☐ 1. College or University
- ☐ 2. Minority College or University
- ☐ 3. Foreign Addressee
- ☐ 4. Minority Business
- ☐ 5. NASA Center
- ☐ 6. Nonprofit Corporation
- ☐ 7. Other Government Agency
- ☐ 8. Private Industry
- ☐ 9. Small Business

Discipline

(check only those that apply)

- ☐ 1. **Life Sciences**
  - ☐ A. Biomedical Physiology
  - ☐ B. Human Factors
  - ☐ C. Bioregenerative Life Support
  - ☐ D. Extravehicular Activity
  - ☐ E. Radiation Biology
  - ☐ F. Space Biology
  - ☐ G. Environmental Health
- ☐ 2. **Microgravity Sciences**
  - ☐ A. Biotechnology
  - ☐ B. Fluid Physics
  - ☐ C. Materials Science
  - ☐ D. Combustion Science

NASA
OFFICIAL MAILING LIST
UPDATE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS
MAIL CODE UP
WASHINGTON, DC 20546-0001

PLACE STAMP
HERE
POST OFFICE
WILL NOT
DELIVER
WITHOUT PROPER
POSTAGE

Please Tape (Do not staple)

40

National Aeronautics and
Space Administration
Code UP
Washington, DC 20546-0001

END

DATE FILMED

08/08/95